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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

American Scientific and Technical Journals.—The great improvement in our American Society and periodical publications, manifested by comparison with similar papers issued ten or twenty years since, can be accepted as the best of evidence of national advance. After taking a general departure from the *elementary* physics, chemistry, mechanics, or decorative or constructive art, the paths have diverged widely in the multiplicity of ways of applied science, and are followed by parties of enthusiastic searchers for novelties or knowledge, each party in the direction of an especial subject of interest, profit or study.

The tendency is to establish separate bodies of society organizations, which seek for members all over the land to obtain that appreciative corps of readers and those audiences which stimulate competition, and give zest to the production of the dryest of documents. The general scientific society, either national or local, must divide

into sections to obtain interesting or intelligent discussion or investigation. General science, alone and of itself, without particular application, it is recognized, is merely childish—the term implies a superficiality incompatible with progress. Our American societies have, therefore, become special and national, and the result has produced a series of society publications during the last ten years quite equal in importance to those which have been printed in any foreign land of the same population. We are a little apt to associate scientific publications solely with those bodies which are called professional; but the race of knowledge is now open to all avocations, and with the mechanical growth of the last century all industrial pursuits have become scientific. It is only within fifty years that chemistry was admitted to form part of a collegiate education. And none of the professions or pursuits which we now call "technical," have the sanction of antiquity as scientific. To-day, however, it is in the papers of the Society of Civil Engineers, the Institute of Mining Engineers, the Institute of Architects, the National Association of Wool Manufacturers, the Railway Master Mechanics' Association, of Master Car Builders, and numerous other associations of similar avocations, that we must look for the highest and most valuable contributions to technical science. The yearly or occasional publications of these societies are replete with novelties and matters of information.

Beside these permanent records, our American technical news journals, most weekly issues, contain not only a supplementary mass of purely technical knowledge, which has been elevated by the influence of the societies to a corresponding standard of excellence, but these journals are also made to be the translators of the language of the avocation which they represent, to the comprehension and instruction of that portion of the public which has to do in business, or any other way, with the particular subject. The list of these periodicals is extended and extending. Their relative circulation and popularity, other things being equal as to merits or display, of course depend on the general usefulness of, or sympathy with, their objects. Thus a paper like the *Architect and Builder*, profusely illustrated and carefully edited, will address itself not only to the professional architects, but also to all of that numerous class who build or wish to build houses, and those who take interest in church or other public buildings. There are none, from the highest to the lowest in

the community, who are not interested in buildings. Chemistry, or mining, or railway engineering may not command so many readers, even if the illustrating and editing are equally well accomplished; while other papers will only find a limited and restricted circulation and sale, with the small community of interested people they address. Patent inventions and novelties in mechanism are objects of absorbing concern to a portion of the community, and are represented by journals of rival, and on the whole, increasing merits. The more abstruse avocations, chemistry, telegraphy, photography, etc., find expression in periodicals of the highest literary attainment, and inform and gratify respective microcosms of specialists, in unknown tongues, incomprehensible to the outer barbarian. Even the minor trades become scientific and literary, and the *Lumberman*, the *Carpet Trade*, the *Tobacco Plant*, add to the stores of human knowledge, until "the ample page" can be no more unfolded, and the "spoils of time" will be lost in the waste basket, or at best, on the old book shelf.

Even the advertisements, in their descriptions and illustrations of apparatus and machinery, form no small nor unimportant part of the information, to be now and hereafter accepted as philosophical and scientific. The free use of the pencil, through the various modes of "illustration" in the current newspapers, becomes a perpetual international exhibition of the latest proposals, as well as of the established practice of mechanism in all branches of trade or manufacture. It has been a popular misconception that the scientific man was to teach the workman—the skilled artificer—the practical manufacturer. The truth is that the record has always until now been behind the accomplishment. The use and value of such record is in the perpetuation of the accomplishment as the starting point of effort by the next person who undertakes to perform the same or a similar task. But now it almost seems as if the record itself will be lost as soon as made in the multiplicity of papers and documents. It will be as finding one's route in a railway guide, to trace out any specific object from the maze of literature.

Not the least valuable or important of our scientific publications are the trades' circular books of some of the larger manufacturing establishments. One could be instanced giving the early history of the locomotive in America; another gives all the details of heating apparatus construction; while the various *tool* circulars unfold the

mystery of workmanship more thoroughly than any text book of science can pretend to. All these together register the advance of year by year with ineffaceable marks—aggregately they are building up the edifice of science, and the American press of to-day is supporting with great and noteworthy ability, the growth of civilization in our country.

With the present number of the JOURNAL, the direction of the present Editor will cease. B.

Franklin Institute.

HALL OF THE INSTITUTE, Feb. 21st, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 123 members and 9 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting 10 persons were elected members of the Institute, and the following donations were made to the library:

Appendix E of annual report of the Chief of Engineers for 1876. From J. D. Kutz

Darwin by R. McK. Ormsby. From the author.

A New Treatise on Steam Engineering, by J. W. Nystrom. 1876. From the author.

Report on the mechanical properties of steel, by W. E. Woodbridge, M. D. 1875. From the author.

Report of the Trustees of the State Hospital for the Insane, Danville, Pa., 1875–6. From the Trustees.

Catalogue of the Rogers Engineering Library of the University of Penna. July, 1875. From Prof. L. M. Haupt.

Fourth Annual Report of the Board of Directors of the Zoological Society of Philadelphia. 1876. From the Society.

Specifications and Drawings of patents issued from the U. S. Patent Office for June, July and August, 1876. From the Commissioner of Patents.

Graphical Analysis of Roof Trusses for the use of engineers, etc., by Chas. E. Greene. Chicago, 1876. From Geo. H. Frost.

Philadelphia and its environs. Die Technik der Baumwollenspinnerei, by Hülsse. Stuttgart, 1863. Gilbart's Treatise on Banking. Dinham's map of the environs of Manchester. The Conservation of Energy, by B. Stewart, 1874. Mechanic's Tool Book, by Harrison, 1868. Religion and Science, by Jos. LeConte, 1874. Handbook of Bookkeeping, London, 1860. Handbook of Business, London, 1860. Phelps' New York City Guide, New York. Der Ingenieur, von Dr. Weisbach, 2d and 3d Vols., 1861 and 1863. Lehrbuch der ebenen Trigonometrie, nebst vielen Uebungsaufgaben, by Dr. Wiegand, 1860. Die Anwendung der Algebra auf praktische Arithmetik, von W. Berkham, 1859. Erster Cursus der Planimetrie, 1866. Die höheren bürgerlischen Rechnungsarten, 1850. Lehrbuch der allgemeinen Arithmetik, 1866, by Aug. Wiegand. From Rob't H. Hoz, Philad'a.

Transactions and proceedings of the Royal Society of New South Wales for 1875, Vol. 7. Mines and Mineral Statistics of New South Wales, etc., 1875. Mineral map and general statistics of New South Wales, Australia, 1876. Transactions of the Philosophical Society of New South Wales, 1862—1865, Sydney, 1866. New South Wales, its progress and resources, by authority of the Commissioners, 1876. Results of Meteorological Observations made in New South Wales during 1873, Sydney, 1875. From the Royal Society, N. S. W.

Forty-third Annual Report of the Royal Cornwall Polytechnic Society, 1875. From the Society.

K. K. Geologische Reichsanstalt. Catalog der Ausstellungs-Gegenstände bei der Wiener Weltausstellung, 1873, Wien. From the K. K. Geol. Reichsanstalt.

Biographical Notes concerning General Richard Montgomery, together with hitherto unpublished letters, 1876. Catalogue of books in the library of the Manchester Literary and Philosophical Society, 1875. Memoires of the Literary and Philosophical Society of Manchester, Vol. 3, 3d Ser., 1876. From the Society.

Report of the Commissioner of Education for 1875. From the Commissioner.

A concise history of the Iron manufacture of American Colonies, etc., by J. B. Pearse, 1876. From the author.

Report of the Board of Commissioners of the State Survey, N. Y. 1877. From the Board.

Rules, regulations and forms of the Canada Patent Office. Sept. 1, 1872. An Act to further amend the Patent Act of 1872. From the Canadian Patent Office.

Polar Colonization and Exploration. From H. W. Howgate.

Bulletin of the U. S. National Museum No. 4. Birds of Southern Mexico, by S. N. Lawrence, Wash., 1876. Bulletin of the U. S. Geolog. and Geographical survey of the Territories, Vol. 2, No. 4. Wash., Aug. 4, 1876. Classification of the collection to illustrate

the animal resources of the United States, by G. Brown Goode. Wash., 1876. The Mineral Wealth, Climate and Rain-fall and natural resources of the Black Hills of Dakota, by W. P. Jenny. Wash., 1876. Report on the Geology of the Eastern portion of the Unita Mountains and a region of country adjacent thereto, with atlas, by J. M. Powell, Wash., 1876. Report of the invertebrate cretaceous and tertiary fossils of the upper Missouri country, by F. B. Meek, U. S. G. S. of the territories, F. V. Hayden, Geologist in charge. Wash., 1876. Vol. 9, and monograph of the Geometrical Moths or Phalænida of the U. S., by A. S. Packard, Jr., Vol. 10. From the Department of Interior, Z. Chandler, Secretary.

Annual report of the Secretary of Internal Affairs of the commonwealth of Pennsylvania, for 1874–5. Part 3. Industrial statistics. Vol. 3. From W. H. Grier.

Fifth and sixth annual reports of the board of commissioners of public charities of the State of Pennsylvania, for 1874–75. Harrisburg, 1875–6. From the board.

Papers relating to the foreign relations of the United States, transmitted to Congress, with the annual message of the President, Dec. 4, 1876. Washington, 1876. From the department of State.

Illustrations to accompany the annual report of the commissioners of Patents, for the years 1869–71. Washington, 1876. From the commissioners of patents.

Twenty-fourth annual report of the president, treasurer and librarian of the Mercantile Library Association of San Francisco. 1876. From A. E. Whitacker, librarian.

The Secretary reported from the Committee on Science and the Arts, that at the last meeting it recommended to the Board of Managers the award of the Scott Legacy Premium and Medal to Geo. B. Grant for his calculating machine, and to G. L. H. Behrns for his high pressure aspirator for ventilating mill stones.

Mr. Wm. Welsh, chairman of the Committee on Primary Industrial Education, reported verbally that the committee had made considerable progress in the work submitted to it, and that the more they study the subject, the more important and timely is the appointment of the committee found to be. He asked that the committee be continued, which was agreed to.

Mr. Geo. R. Moore was then introduced and read the paper announced for the evening, on Schools for Inventors.

The Secretary presented his report which embraced Clark's Compound R. R. Rail; Robinson's Odontograph for laying out the teeth of gear wheels; Morris, Wheeler & Co.'s chisel-pointed Nail; an exhaust Nozzle for quieting the noise of safety valves, escape pipes,

etc., the invention of Mr. Thos. Shaw; Behrns' Aspirator for ventilating millstones; a Horseshoe intended to prevent slipping on smooth pavements; a new form of Megascope, designed by J. B. Knight, and the Wallace-Farmer Magneto-Electric machine, built by Messrs. Wallace & Sons, of Ansonia, Conn. One of these machines, loaned by the builders to the Committee on Instruction for use in lectures, was in operation on the stage and its power was shown by vaporizing metals, etc., and its construction and action explained at some length by the President.

The Magneto-Electric machine was driven by an upright steam engine of 6 in. diameter of cylinder and 8 in. stroke, recently purchased by the Institute from Mr. Jacob Naylor.

Under the head of new business, the Resolution of Mr. F. M. M. Beale, relative to Polar Exploration, postponed from the last meeting, was taken up and on being put to a vote was adopted, as follows:

WHEREAS, A Bill is at present pending before Congress asking aid for carrying into execution the scheme of Capt. H. W. Howgate, of the Signal Service, for reaching and exploring the region about the North Pole on the plan of colonization,

Resolved, That the Franklin Institute approves of this plan, not only for its economy, but for its apparent practicability, and believes it to be the most feasible plan yet offered.

On motion of Mr. Orr, it was

Resolved, That the Secretary be directed to send a copy of above Resolution to both Houses of Congress.

On motion the meeting adjourned.

J. B. KNIGHT, *Secretary.*

Donations continued from January Number.

Annual Report of the New York Meteorological Observatory for 1874–5, by D. Draper, Director. From the Director.

Bibliotheque Universel et revue suisse, N. 217, with table des travaux de la revue, etc. Note sur les elèves externes de l'école des Ponts et chaussées par M. Malézieux, Paris, 1875. Ecole des Ponts et chaussées. Cour preparatoires. Catalogue du Cercle de la libraire de l'imprimerie, etc. Paris, 1876. Exposition Universelle de Philadelphia, 1876.

Etude historique et statistique sur les voies de communication de la France, etc. Par M. Felix Lucas, Paris, 1873. Exposition Univ. à Vienne.

Catalogue descriptive des Modéles, Instruments et dessins des galeries de l'école, par H. Baron, Ing.-en-Chf, Paris, 1873. Ecole National des Ponts et chausseés. From E. Lavoinne, Delegate from French Government.

The Economy of Workshop Manipulation, etc., by John Richards. From the Author.

Second Geological Survey of Pennsylvania, 1874–5. Report of Progress in the District of York and Adams Counties, etc. By Persifor Frazer, Jr. Harrisburg, 1876. Report of Progress in the Greene and Washington Districts of the Bituminous Coal Fields of Western Pennsylvania, by J. J. Stevenson, Harrisburg, 1876. From the Board of Commissioners, through their Secretary, Mr. J. B. Pearce.

Instruments and Publications of the U. S. Naval Observatory, 1845–76. Five Photographs of Planet of Saturn, etc. Five Photographs of Drawings, made with 26 in. equatorial in 1875. One Engraving of U. S. Naval Observatory, Washington. From U. S. Naval Observatory, through Prof. J. E. Nourse, Washington.

Extracts from the Proceedings of the Board of Regents of the Smithsonian Institution in Relation to the Electro-Magnetic Telegraph. From Prof. W. S. Cooley.

Twenty-fourth Annual Report to the Council of the City of Manchester, on the Working of the Public Free Libraries, 1875–6. Manchester, 1876. From the Council.

History of the Cooper Shop Volunteer Refreshment Saloon, by Jas. Moore, M.D. Philadelphia, 1866. From Mrs. A. Horner, Philadelphia.

Sections of Steel and Iron Rails Manufactured by Cambria Iron Co., Johnstown, Pa. From the Company.

Minutes of Proceedings of the Institution of Civil Engineers, Vol. 46, Session 1875–6, Part 4. Edited by Jas. Forrest, Secretary. London, 1876. From the Institution.

Catalogue of the Argentine Republic, International Exhibition, Philadelphia, 1876.

Catalogues des produits industrielles et des œuvres d'art de Belgique. Exhibition International, Philadelphia. Bruxelles, 1876.

The Empire of Brazil at the Universal Exhibition of 1876, in Philadelphia. Rio de Janeiro, 1876.

Catalogue of the Brazilian Section, Philadelphia International Exhibition, 1876.

Official Catalogue of the British Section, Part 1, Philadelphia International Exhibition. London, 1876.

Centennial Newspaper Exhibition, 1876. N.Y.

Ceremony of the Distribution of Awards to Exhibitors in the International Exhibition, Philadelphia, 1876.

Lista preparatoria del Catalogo de los expositores de España y provincias de Ultramar, Cuba, etc., Exposicion Universal de Filadelfia en 1876.

Oeuvres d'art et produits industriels de France. Exposition international, Philada., 1876.

Official Catalogue of the German Department, International Exhibition, Philada., 1876. Berlin, 1876.

India. Classified and descriptive catalogue of the collections selected from the India museum, and exhibited in the Indian Dept. of Philadelphia Centennial Exhibition of 1876. By J. F. Watson, London, 1876.

Catalogo general de los productos y objetos de las Islas Filipinas remitidos a la Exposition Universal de Filadelfia, 1876. Manila.

International Exhibition, 1876. Official catalogue of the seven departments in 4 Vols. Philadelphia.

Official catalogue of the Japanese section, and descriptive notes on the industry and agriculture of Japan. International Exhibition, 1876. Philada., 1876.

Jamaica. Descriptive catalogue of the collection sent from the Island to the Centennial Exhibition of 1876. Compiled, etc., by R. Thomson. Jamaica, 1876.

Kansas. Centennial edition of the fourth Annual Report of the State Board of Agriculture to the Legislature of the state, 1876.

Special catalogue and explanatory notes of the Mexican section, Philada. International Exhibition, 1876. Philadelphia, 1876.

History of Nassau, N. P., Bahamas.

Ohio. An address, delivered at the Centennial Exhibition in Philadelphia, August 9th, 1876, by E. D. Mansfield. Cleveland, 1876.

Sketch of Orange Free State of South Africa. Issued by the Commissioner at the Int. Ex., Philada., 1876.

Oesterreichischen Abtheilung. Katalogue. Weltausstellung in Philadelphia, 1876. Wien.

Annual report of the packing of the West, etc., compiled by B. F. Howard. Chicago, 1876.

Catalogue of the Educational exhibit of the state of Pennsylvania, with an appendix, containing an outline of the system of public instruction in the state, Centennial Exhibition. Lancaster, 1876.

Official catalogue of the Peruvian section, Main building, International Exhibition, Philad'a, 1876. N. Y.

Catalogue of the Russian section, International Exhibition, Phila., 1876. Russia, 1876.

Special catalogue of stated displays of Live stock, International Exhibition, Philadelphia, Oct. 10–18, 1876.

Official catalogue of exhibits, essays, etc., of Victoria, Australia, Philada. Centennial Exhibition, 1876. Melbourne, 1876.

Resources of West Virginia, by Maury & Fountaine. Wheeling, 1876. From P. C. De Sangue, Philad'a.

Public Libraries in the United States of America, their history, condition and management. Special report Dept. Interior, Bureau Education, parts 1 & 2. Washington, 1876. From Hon. Com. of Education.

Programm der Grossherzoglich Badischen Polytechnischen Schule zu Carlsruhe, für das Studienjahr 1866–67.

Astronomie geometrique ou brèves considerations sur les nouvelle theorie des ovhélites, par le Comte Leopold Hugo. Paris, 1876.

Ueber die Entstehung des Schwärmsprösslings der podophrga quadripartitæ. Clp. u. Lehm, etc., von Dr. Otto Butschli. Naumburg, 1876.

The Empire of Brazil at the Universal Exhibition of 1876, Philadelphia. From the Smithsonian Institution, Washington.

Donations continued from February Number.

Reports upon geographical and geological explorations and surveys west of the one-hundredth meridian in charge of first lieut. Geo. M. Wheeler. Vol. 3, geology; vol. 5, zoology. Washington, 1875.

Report of the exploring expedition from Santa-Fé, New Mexico, to the junction of the Grand and Green rivers of the Great Colorado of the West, in 1859, under command of Capt. J. V. Macomb, with geological report by Prof. J. S. Newberry. Washington, 1876.

Report of explorations across the great basin of the territory of Utah, for a direct wagon route from camp Floyd to Genoa, in Carson valley, in 1859, by Capt. J. H. Simpson. Washington, 1876. From the war department.

(To be continued.)

Book Notices.

A Concise History of the Iron Manufacture of the American Colonies up to the Revolution, and of Pennsylvania to the Present Time. By John B. Pearse, A.M. Allen, Lane & Scott, Philadelphia, 1877. 12mo, 282 pages, with Map of Pennsylvania. $2.00.

Those who are interested in the history of our country, as readers or as students, as well as those engaged in the iron trade or manufacture, will turn with much pleasure to this interesting narrative

account of the origin and growth of the iron manufacture in our country. Other metallic productions may inure to the luxury or wealth of a people, as the possession of gold and silver fostered the greatness of Spain in the days of its prosperity; but it is the manufacture of iron that, paramount to all other industries, develops the labor and establishes the independence of a nation. In these modern times especially, the measure of the civilization of any nation is founded on the construction and employment of the mechanism involved in the uses of iron and steel.

In the preface, "The author hopes that the publication of the book at this time may bring to light additional facts, so that at some future time he may have the opportunity to complete it, and include all the States as thoroughly as Pennsylvania." With this purpose in view, it would have been much better if he had given the sources of information from which it was compiled. Even a bibliographical list would have sufficed, but it would have been yet better to have placed foot-notes of authorities for each statement, which would not have encumbered the text with matter wanting in interest to the general reader, while they would have given a historical accuracy and importance to the book, which it now wants.

The history, or accessible record of iron making, is considered in the several Provinces, commencing with Virginia and following with other Colonies in their order of settlement, and tracing, with some regard to chronological sequence, the origin and progress of the industry. It is unavoidable, in the compilation of material of this kind, that some of the information should come to hand too late for the preservation of perfect continuity of narrative; but no material changes, none that the reader will not at once effect in his own mind, will be demanded to give the proper historical arrangement of events.

Some of the deductions are a little incongruous. Thus we read, under the head of "Massachusetts": "Notwithstanding the early progress of Virginia, the colony of Massachusetts Bay was neither idle nor far behind Virginia in making iron. Virginia made, indeed, the first iron, but very little of it, and the attempt was abandoned before Massachusetts began." * * * "The first iron works in Massachusetts was that at Lynn, mentioned in the records of the Sixth Church of Christ, held at Lynn, 1631" * * * "Here is also an iron mill in constant use." This record causes one to look

back to Virginia, and see what was the early progress referred to. "The first iron made in this country was made in Virginia. Capt. John Smith early called attention to iron ore in Virginia, and Sir Thomas Gates (1610) mentioned iron ore ten miles in circuit, of which we have made trial at home [in England]; that it makes as good iron as any in Europe. In April, 1608, ore was sent from Jamestown to England, which was smelted in the autumn, yielding seventeen tons of pig metal," a fact which is corroborated by the statement that "it was sold to the East India Company for £4 sterling per ton." Sir Edwin Landys (1620) says that "one hundred and ten iron workers from Warwickshire and Staffordshire, and forty from Sussex were sent to Virginia to erect three iron works." One of the proposed three is stated to have been commenced, and it was "certified by Mr. Berkely, that by Whitsuntide next (1622) iron would be made." "But, alas! in 1622 (March 22d) Mr. John Berkely, with twenty-two men, two women and three children, were massacred by the Indians, and the works destroyed before they got into the body of the mines (Beverley). *The iron proved reasonably good* [the italics are the reviewer's]. Maurice Barkley was directed to employ the survivors, and rebuild the works; but in 1624 the Virginia Company was dissolved by royal decree, and the whole enterprise fell to the ground." There does not appear to be any evidence that iron was made in Virginia at that time, nor at any other prior to 1715, except by inference.

It will probably be found, if this book stimulates inquiry amongst the old records, that the Colonies, from the first years of their settlement, produced more or less forge iron in a small way. The colonists included numbers of working mechanics. Emigrants are always mainly tradespeople and working men. Farmers and farm laborers have a land attachment, which it is difficult to break. And the smith's art is the earliest to find employment in a new settlement. Under the protection of the heavy cost of bringing iron from the mother country, and the absolute want of money or exchangeable commodity to pay for it, with the advantage of a more than abundance of wood to make charcoal, while the forests of England were even then in good part cut away—under these circumstances the making of iron was stimulated at once into a business. The little forges wherein wrought iron was made by the sinking process were probably numerous, although as few records would remain of them, as

of the shoemakers' benches or bakers' ovens. While the larger furnaces, or bloomeries, or hammer mills, which would follow the growth of the settlement, would be matters of public regard and note.

The policy of Great Britain towards the Colonies, the effort, as they grew stronger, to preserve them in utterly dependent positions, the course of protection of her home industries, the intelligent pursuit of which has finally made her the seat of the arts and sciences, the mistress of nations, is strikingly exemplified in one part of this book.

The reader will find on referring to pages 121 and following, the Act of Parliament of 1749. "*To encourage the Importation of Pig and Bar-Iron from His Majesty's Colonies in America into the Port of London and to prevent the Erection of any Mill or other Engine for Slitting or Rolling of Iron; or any Plating Forge to work with a Tilt Hammer or any Furnace for making Steel in said Colonies.*" A very brief summary of this Act is as follows:

The Act was to go into effect on the 24th of June, 1750; it abolished all duties then in force on colonial pig or bar iron imported into any part of England, and permitted pig or bar iron to enter the port of London free of duty, but it was not permitted to enter iron at any other place in the kingdom of Great Britain, and after its arrival at London it could not be shipped from London or transmitted by land further than ten miles, in any unmanufactured state. Ships transporting were to be forfeited and seized—punishments and penalties awaited masters or commanders—forfeitures and fines were to be inflicted on carriers on horseback, in wagon, cart or carriage.[1] Every bar was to be stamped in three places (and forging of a stamp was a capital crime, to be punished by hanging in those days).

"No Mill or other Engine for Slitting or Rolling of Iron or any Plating Forge to work with a Tilt Hammer or any Furnace for making Steel shall be erected, or after such Erection continue, or cause to be continued, in any of the said Colonies, under penalties of £200, for such Mill, Engine, Forge or Furnace. Such Mill, Engine, Forge or Furnace so erected or continued * * shall be deemed a common nuisance and abated accordingly, with forfeiture of £500 by the

[1] In 1756, the trade was made free to any port in Great Britain, and in 1765, to any port in Ireland, but otherwise the law, with its restrictions against Slitting, Rolling, Plating or Steel making, remained in force until the Revolution.

offender, and disability to enjoy any office of Trust and Profit under His Majesty, his heirs and successors."

Following the suggestion of the author as to the eliciting of new facts on this subject, it is ventured to publish the accompanying correspondence and memorial from the original manuscripts in possession of Henry Pemberton, Esq., of this city, relating to this Act.

The writer, Richard Partridge, Esq., was then Agent of the Province of Pennsylvania, in London, and his correspondent, John Kinsey, Esq., was Chief Justice of the Province.

London 12 *mo. the* 28*th* 1749.

Lo: Frd: John Kinsey

I wrote thee of the 22d & 26th ult. by the late ships for Philad^{a} to which I refer—& now I was not willing to omit sending thee a few lines by this conveyance also—

I think I mentioned something to thee of a Bill that was brought into the House of Comons for taking off the Duty on Iron Bars & Pig Iron imported from the Plantations, but since that a clause is added to the Bill for preventing their making Steel & Setting up of Slitting Mills & Rolling Mills in the said Plantations which we apprehend would greatly tend to their prejudice & be an Infringement on the priviledges of the Charter—And thereupon I have drawn up some Reasons agst that Clause which I yesterday communicated to your Proprietor Penn who approved it proposing only a little variation & a small addition, which we intend to make a proper use of as there shall be occasion, a copy whereof comes inclosed. But altho the Bill is espoused by the Ministry yet it is thought there will be such opposition to it from some of the Countys that it will hardly pass—

Nothing yet is passed in the House this Sessions relating to Paper Currency I am Thy real friend

R^{d} Partridge

Objections against a Clause in the Iron Bill

To prevent the making of Steel and Setting up Slitting Mills and Rolling Mills in the British Colonies in America

That the Province of Pennsylvania & New Jersey & the Colony of Rhode Island have been peopled & at great expence settled by means of certain Priviledges which were granted by the Crown & have shown the utmost Duty at every Intimation of the Royal Pleasure & have made such Reasonable & prudent use of those Indulgences w^{h} have been granted by the Crown that the said Provinces and Colony are now become flourishing Plantations in his Majesty's American Dominions

That by Virtue of Charters granted by King Charles the Second, the People who should Settle & Inhabit within the said Provinces and Colony should have and enjoy all libertys & Immunitys of Free & natural Born Subjects to all Intents Constructions & Purposes whatsoever as if they were born in the Realm of England.

That the Several Tracts of Lands together with all Mines, Minerals &c were for their Encouragement by the said Charters granted to the respective Proprietors as their own & intire Property

That the said Provinces & Colony did at their own Expence and without any charge to the Crown, Settle, Inhabit, Cultivate & improve the Lands of a Wilderness Country well hoping that they and their Successors should constantly for ever enjoy all and every those Libertys Franchizes & Priviledges so granted by the Royal Charters who have approved themselves dutyfull & Loyal Subjects of great and singular advantage to this Kingdom, by taking off vast quantitys of the British manufactures Annually

That the Clause aforesaid for preventing the making of Steel and Setting up Slitting & Rolling Mills in the British Colonies in America now depending in the House—It is humbly presumed will be exceeding prejudicial and discouraging to the Inhabitants of the said Provinces and Colony in that there are diverse sorts of Iron Materials constantly wanted & in use amongst them to be made out of Rods of Iron which cannot readily be had from their Mother Country nay impossible to be accommodated with suitable to the Necessitys required Particularly Horse Shoes & Horse Shoe Nails, so absolutely necessary that without them their Horses (of which there are great Numbers) wou'd be render'd in a manner useless; and Iron Screws & Rods for their Bedsteads & other Household furniture with innumerable other things necessary for Carpenters & Joyners work &c

That the Proprietors of the Slitting Mills already erected in some of the said Plantations, have been at very great expense in building & Setting them up which should such a Law pass as is now proposed would be a very great hurt & damage to their Property.

That Steel is absolutely necessary for working up their Edge Tools Particularly their Axes for Felling their Timber Trees which beside their Iron there is most properly Suitable for the Purpose; they are made in such a peculiar manner, & which the People of that Country are accustomed to.

That as the Inhabitants of the said Provinces and Colony are by His Majesty's Royal Grants as aforesaid allowed to be Free Dennisons as any of his Subjects born in this Realm so they cannott but esteem it avery great hardship and an Infraction of the said Royal Charters now after so long a time of Enjoyment of their Priviledges and Immunitys as English men to be deprived thereof by being debarred of that natural right of Improving to the best advantage what Nature hath put in to their hands so absolutely necessary for the Conveniences of Life.

Added by y^r^ Propriet. Penn

And it is further conceived that this Clause will not be of Advantage to Great Britain as by how much of the Iron Manufactures it will oblige them to take from this Kingdom by so much less they will have to pay for Woolen Manufactures which the Severity of their Winters render very necessary to them.

And therefor for these Reasons it is humbly hoped the said Clause will be rejected.

It would be highly gratifying to the writer of this notice to pursue this interesting book through the more modern record of iron making in the United States; but the limit of space in the JOURNAL is already reached, if not surpassed. Now that a point of aggregation has been established, it is to be hoped that contributions will flow in upon Mr. Pearse, so that he can at a future time add considerably to this history. The reviewer is unwillingly obliged to conclude in recommending Pearse's History of the Iron Manufacture as worthy to be read and preserved as a standard work in the general history of our country, and in the progress of the arts, as applied in the wider sense to the world's advancement. B.

NEW ENCYCLOPEDIA OF CHEMISTRY. Lippincott & Co., Philadelphia, 1877. Issued in 40 parts (Parts XVI to XX now published), at 50 cents each.

The previous favorable notices of this admirable work are fully supported in its continuation. As a book of reference in practical chemistry, it is alone amongst the recent encyclopedias. For the operating chemist it gives a record, down to the present hour, of applications which have stood the test of actual use; and for the manufacturer of any product, who would know the relations of chemistry to his business, it contains the most ample description of processes and results. Being based on a former standard of the highest excellence, its completeness is insured by the additions which are liberally made, until, without deserting any of the old store of knowledge, the whole is, in effect, a new work, giving the present condition of chemical arts, with all its change and growth for fifty years.

GRAPHICAL ANALYSIS OF ROOF TRUSSES, by Chas. E. Greene, A. M., Prof. of Civil Engineering, University of Michigan. Pp. 64, 8vo. G. H. Frost, Chicago, 1876.

This republication of Articles on Roof Trusses, which first appeared in the *Engineering News*, in such form that it will be a convenient book of reference to go on the shelves of the engineer or architect, is very satisfactory, as the study really possesses so much value in constant practice as to make this disposition of it desirable.

So many references to the graphical consideration of stresses have appeared in the JOURNAL during the past three years, that the readers must fully appreciate the estimation in which the method is held by the editorial direction, and this presentation of Prof. Greene will be found at once simple, clear and reliable, and hence can be highly recommended. B.

Civil and Mechanical Engineering.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S. B.

[Continued from Vol. ciii, page 113.

The Mack's injector with which this locomotive is supplied, is of the fixed nozzle, lifting form, and has been exclusively used upon the engines of the Eastern road since 1872. The diameter of the connections of the No. 6, is 1¼ inches; it will lift water from five to eighteen feet, at from 15 to 40 lbs. pressure, and deliver 870 gallons per hour, or from 116 to 134 cubic feet of water at 120 lbs. pressure. The rule by which they are ordered is, assuming the nominal horse power of the boiler to be equal to the number of square feet of heating surface divided by 15, for a multitubular boiler, each nominal horse power will require 7½ gallons of water per hour, and the capacity needed is so determined.

To show the general arrangement of parts, the position and principle of this injector, I have drawn it in its real position upon the boiler in plate *A*, and made the following sectional view. Its position is horizontal and in this case just above the running board. Its parts consist of a starting valve *A*, the steam pipe *B*, conical *receiving*, *combining*, and *delivery* tubes, shown respectively at *b*, *c*, and *e*, in the sectional view, the steam spindle *I*, water regulating handle *H*, water supply pipe *C*, overflow pipe *E*, the delivery pipe *D*, and check valve *F*.

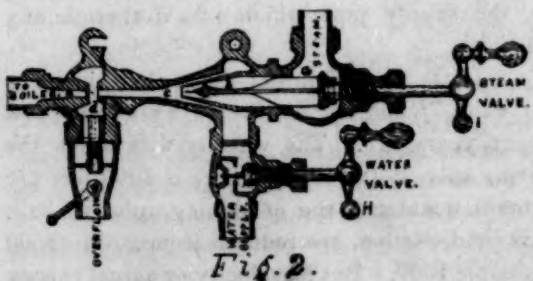

Fig. 2.

It may be operated by opening the three valves *A*, *H* and *I*, in various orders, and its action may be described as follows:—To start the injector, the steam valve *I*, is first opened, by which any condensed steam in the apparatus is blown out through the overflow which opens into the air within the cab. Then, 1st, the water valve *H*, is opened, which causes a stream of water to flow through the supply pipe *C*, plate *A*, through *c* and *d*, Fig. 2, and out at the overflow. 2d, the starting or steam valve *A*, is opened from one-eighth to one-fourth of a turn. By this means dry steam from the boiler enters the injector at *a*, and passes by the feathers of the steam spindle *b*, which is in what is called the receiving tube, since it receives the live steam from the boiler. It thence passes into the combining tube *c*, where it is condensed by the water, and without losing its own velocity, imparts an additional velocity to a portion of the water which it takes up, carries across the opening in the overflow *d*, into the delivery tube *e*, and pipe *D*, in the plate, and forces through the check valve *F*, into the boiler. 3d, the steam spindle is next fully opened, by which more and more of the water is taken up; and 4th, if any remains flowing out through the overflow, it is cut off by slowly turning off the water valve *H*. To stop its action, the steam valve *A*, the water valve *H*, and the steam spindle *I*, are in succession turned off.

Such, in brief, is the action of this instrument in its simplest form. In the self-regulating form, the combining tube *c* is movable, and its distance from *b* regulated by a piston, acted upon by the pressure of the overflow water. This piston, by moving the tube *c* against the outside of *b*, cuts off the water supply; and the injector has also an alarm check valve in the supply pipe, which lifts if there is any failure of the valves to work.

The principle of the injector is as follows:—It is that known as the "lateral action of fluids,"[1] and was discovered by Venturi and Nicholson, about seventy years ago. The velocity with which the steam enters the receiving tube at 120 lbs. pressure is 1900 feet per second, and on reaching the water in the combining tube, its bulk and cross-section, by its condensation, are reduced from 200 to 1500 times; let us say for example 1000. But its velocity or actual energy

[1] Roper's Handbook.

is not destroyed as it comes in contact with a thin ring of water, which would be the case if it encountered a large mass, and it is hence communicated to the water, whose energy, proportional to its weight, multiplied by the square of its velocity, drives it into the boiler against the steam pressure, with great momentum. It is equivalent to concentrating the original force due to the pressure of the steam upon a cross-section of but $\frac{1}{1000}$ of its original area.

The injector is the most elegant of all the applications of science for practical use, in the locomotive.

Connected with the subject of boiler feed is that of *feed water heaters*, into the discussion of which I will not here enter. The utility of these arrangements lies either in the use of the waste heat of the furnace or of the enormous amount carried off by the exhaust steam. The difficulties which stand in the way of their use are, that the former are complicated and expensive to keep in repair and obstruct the course of the gases through the smoke-box, and the latter tend to lessen the draught through the smoke-stack, while in both the saving theoretically demonstrable is much diminished if not neutralized by the items of expense in first cost, interest, deterioration and repairs, complexity and the increased liability for the engine to get out of order.

Mr. M. N. Forney[1] states the ruling principle by which to decide in each case whether there is at present any real benefit or not from their use, to be this,—"if it diminishes the maximum capacity of the engine for pulling cars, it diminishes the efficiency in the same proportion." Although the Magoon heater is simple in design and has been in use upon the "Saxon," on the Boston and Maine Railroad, where it is said that it caused a saving of about three-quarters of a ton of coal per day, for four months in succession, and the apparent saving by its use is a matter of very easy calculation, yet I have the opinion of one[a] most interested in effecting such saving, who says that all such contrivances, including the spark arresters, are not as efficient as representations would seem to show, and the fact that they are not universally used after having had a fair trial would seem to indicate that there is at present no real gain in economy by their use.

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[1] In Ed. *Railroad Gazette*, Sept. 11th, 1875.

[a] Mr. Jno. Thompson, Master of Machinery, E. R. R.

IV. The Safety Apparatus forms a large portion of the locomotive boiler fittings. It may be classed as of two kinds, those parts which insure the safety of the boiler directly, and those which are added for the protection of the engineer and his train, and the public. The first of these are the safety valves, steam gauge, water gauges, gauge cocks and lead plugs, formerly used in the crown sheet of the fire-box; the second includes the air or vacuum brake, the steam dome and whistle, the bell, head-light, spark-arrester, running boards, hand-rails, foot-board, cab, wheel-guards, pilot, down to the brooms of steel wire, by which small obstructions are removed from the rails. The spark-arrester in this locomotive, consists in the wire netting stretched between the cones, placed base to base, which form the upper part of the smoke-stack. The office of these is, the first, by enlarging the cross-section of the pipe to diminish the velocity of the particles of coal, and the second, or upper, to deflect them downward again. The two pieces of apparatus first mentioned only, need further description, the others being indicated in plate *A*, of the drawings, and in the specification.

Of the Steam Gauge there are a number of forms, such as the Bourdon, Edson, Allen, Crosby, and Lane. The principles upon which they all work are, in one class, the moving of an index over a graduated arc by means of the pressure of steam acting upon an elastic diaphragm, in a similar manner to that in an Aneroid barometer; or in the other, upon a curved tube of flattened cross-section.

Bourdon Gauge.
Fig 3.

The gauge with which this locomotive is supplied, is the Bourdon form, having Lane's improvement, and manufactured by the American Steam Gauge Co. in Boston.

Both the original and its modified form are exhibited by the accompanying figures.

Lane's Improvement.
Fig. 4.

On account of the importance of this instrument to the locomotive boiler, a short description of its construction, from observations made during an afternoon's visit to the American Steam Gauge Company's Works, may be given.

The principle of the Bourdon gauge was discovered in rather a curious way, by Mr. Bourdon, a coppersmith, of Paris. A worm for a still, which he was repairing, having accidentally become bent or indented, and thinking that by applying internal pressure on the pipe the dent could be removed, he did so, and observed, to his surprise, a slight motion of the coil. From this he was led to a study of the cause of the tendency he observed—that of a bent tube of flattened cross-section to straighten when subjected to internal pressure, and invented the first form of steam gauge. Previous to its use, the manometer, or short mercury column, and the lever and spring balance attached to the safety valve, and provided with an index and scale, were the only arrangements for the indication of pressure upon locomotives. On this discovery the Bourdon gauge was constructed, and introduced by Mr. E. H. Ashcroft, about a year later, into this country, in 1851. As shown, it consists of a tube, having an elliptic cross-section, bent into a circular form, and attached, by one extremity, *a*, to the case, communication being made between its interior and the steam pressure through the pipe below. The other end moving, turns the lever *b*, and the toothed segment, which at one end gears into a pinion *c*, and so gives motion to the hand.

Although in this gauge there was a bend, or U, in the pipe connecting the boiler and the gauge, for the purpose of collecting the condensed water, it was found that a detached portion of water would remain suspended midway between the extremities of the curved tube, and often burst it by freezing, or cause inaccuracies in the indications. This is now prevented in Lane's improved form. The tube is held at the middle, *a*, Fig. 4, one end, *b*, connected with the lever, *d e*, which has a toothed segment, turning a pinion on the spindle of the index, as before. If the end, *b*, moved alone, *c* would be the fulcrum of this lever; if *c* alone moved, the lever would turn about *d*. As both ends, however, move apart together, when under internal pressure, the motion of the whole is utilized, as in the old form, and much greater steadiness obtained. From the construction any water in the ends of the tube would run out, and, in practice, the ends of the tube contain compressed air. The curved tube is originally straight and round, $\frac{5}{8}$ inch in outside diameter, and made of a hard composition. By repeatedly drawing

through dies, its elliptic cross-section is produced of the following dimensions:

Fig. 5.

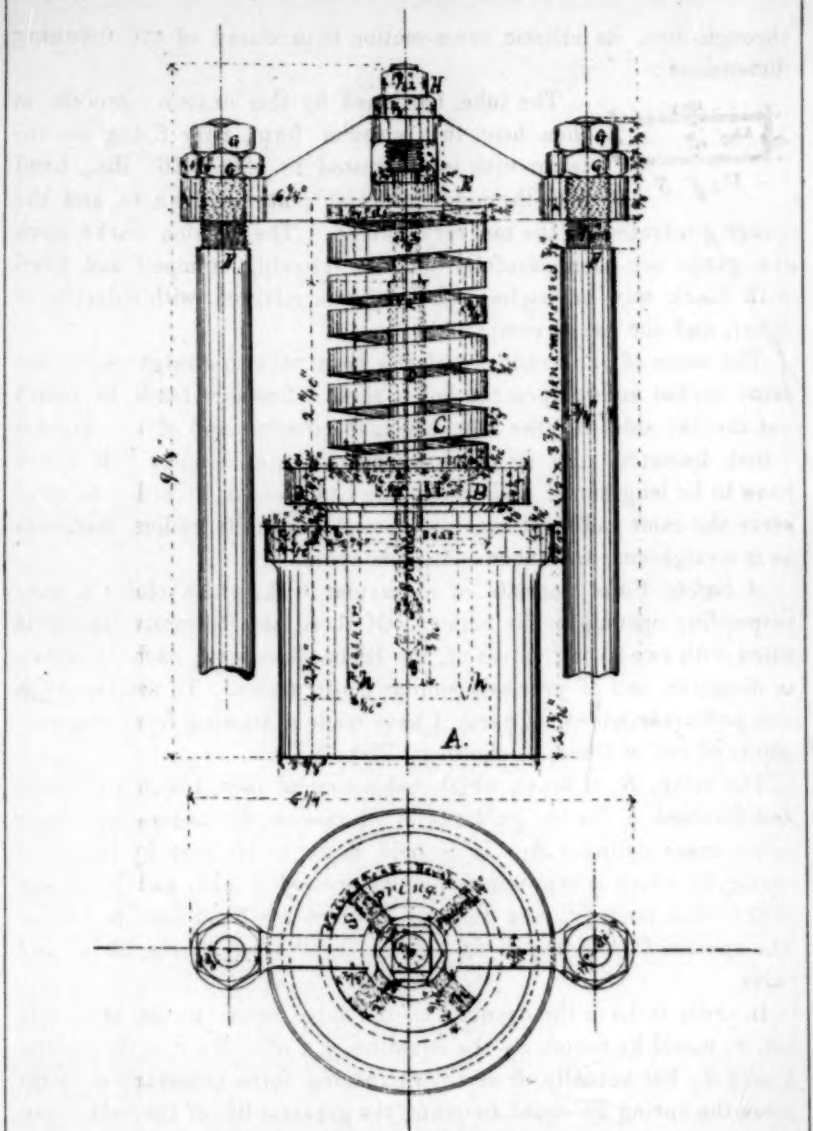
The tube, hardened by this drawing process, is then bent into circular form, after filling its interior with sand; tested to 150 or 160 lbs.; fixed with the index and dial plate in the case, and the gauge graduated by the mercury column. The division marks upon the gauge are then carefully cut, the lettering stamped and filled with black wax, or asphaltum, the brass silvered with chloride of silver, and the gauge completed.

The cause of the tendency of the bent tube to straighten, is the same as that acting upon the boiler shell. Pressure tends to round out the flat sides till the tube becomes circular, and of its original $\frac{3}{8}$ inch diameter. As it approximates to this, its outer side would have to be lengthened and inner side compressed, in order to preserve the same radius of curvature; and hence its radius increases as it straightens, and throws the ends apart.

A Safety Valve consists of a circular disk, which closes a corresponding opening in the boiler. Of these, the locomotive boiler is fitted with two spring valves of the Richardson form, each $2\frac{1}{4}$ inches in diameter, and of precisely similar construction. To illustrate the size and arrangement of parts, I have made a drawing from measurements of one of these, as shown in Plate VI.

The valve, *B*, of brass, which has a conical face $\frac{1}{8}$ inch in depth, and feathers, *h*, for the guidance of its motion, fits accurately a seat in the brass cylinder *A*. It is held down to its seat by the steel spring, *C*, which is represented as compressed $\frac{3}{8}$ inch, and by means of the cross piece, *E*, and bolts, *F F*, which are fixed into the boiler. The spindle *D*, and the screw bolt *H*, serve to adjust the lift of the valve.

In order to have the opening of the valve equal to its area, this lift, *h*, would be found, by the equation, $\frac{1}{4}\pi d^2 = 2\pi r \times h$, whence $h = \frac{1}{4} d$; but actually, from the increasing force necessary to compress the spring by equal amounts, the greatest lift of the valve may be taken at $\frac{1}{20}$ of an inch. Now, since the coning of this valve is 45°, the real opening for the escape of steam is but $\frac{7}{10}$ of the lift, or $\cdot 05 \times \cdot 7 = \cdot 035$ inch. To show plainly what this amount is, the figure below has been drawn *full size*.



Richardson's 'POP' SAFETY VALVE for Locomotives.

Scale 3/8" = 1'

F.E. Galloupe.

The area thus opened for the passage of the steam is but $2\pi r \times \cdot 035 = \cdot 2474$ square inch, corresponding to a pipe a trifle over $\frac{1}{2}$ in. in diameter. Prof. Burg, of Vienna, has found, from actual measurements, that at only 12 lbs. pressure the rise was but $\frac{1}{36}$ inch, and that it rapidly *decreased with increase of pressure*, till, at 90 lbs., the opening was but $\frac{1}{168}$ inch. With the rise of $\frac{1}{20}$ inch, the pressure necessary to keep the valve open increases at least 5 lbs.

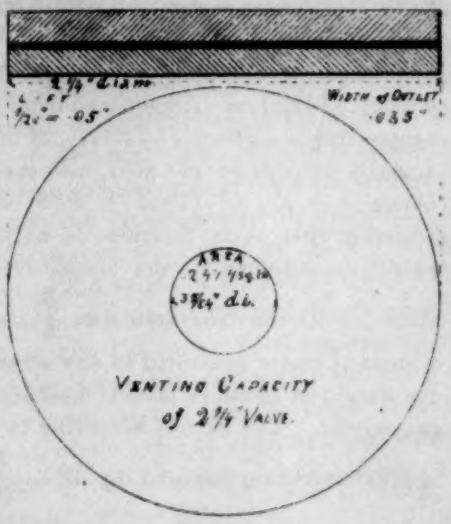


Fig. 6.

The safety valves of the locomotive should each be sufficient to discharge all the steam that the boiler is capable of generating; that is, they should be of sufficient capacity to discharge the steam as rapidly as it can be formed. At 140 lbs. pressure we have found that the amount of coal capable of being burned per hour is 1,855 pounds, or 0·517 pounds per second. The corresponding evaporation per second would be $\cdot 517 \times 6 \cdot 08 = 3 \cdot 143$ lbs. of water. The relative volume of steam at this pressure is 182·6, and multiplying by ·016, which may be taken as the volume of 1 lb. of water, there will be 2·92 cubic feet of steam for each pound of water evaporated. Hence, the maximum volume of steam which the safety valves should accommodate is $2 \cdot 92 \times 3 \cdot 14 = 9 \cdot 1688$ cubic feet per second. The theoretical velocity of steam flowing into the atmosphere, at this pressure, is about 1947 feet per second. The small area of safety valve actually used is much less than that given by either of Rankine's two rules, or by the rules of Bourne or Wilson, or even by the formula of efflux, $v = \sqrt{2gh}$.

Applying Mr. Bourne's formula, $a = A \cdot \frac{V}{300\ P}$, where A equals the area of the piston (in square feet?) $= 1 \cdot 39$ square feet, V equals its velocity in feet per minute, $= 2200$ feet, and P equals the effective pressure, or, in this case, 140 lbs., we find the required area

to be 76·1 square inches. By Rankine's first rule, that the area a, in square inches = from $\frac{1}{25}$ to $\frac{1}{30}$ of the number of pounds of coal burned per hour, taking the smallest fraction, we obtain: $a = \frac{1}{30} \times 1855 = 61{\cdot}8$ square inches; and, by his second, that a in square inches = from $\frac{1}{150}$ to $\frac{1}{180}$ of the number of pounds of water actually evaporated per hour, also taking the smallest fraction, we obtain $a = \frac{1}{180} \times (1855 \times 6{\cdot}08) = 62{\cdot}6$ square inches. It is probable that these formulæ do not at all take into account the peculiar conditions in the locomotive boiler. Mr. Robert Wilson states a rule that the area $a = \frac{S}{W}$, where S equals the number of pounds of steam generated in one second, or 3·153 lbs., and W equals the weight of steam in pounds discharged per square inch of opening per second. The latter, according to Mr. McFarlane Gray, may be approximately represented by $W = \frac{P}{70}$, where P is the pressure in pounds per square inch above zero. Hence, $W = \frac{140}{70} = 2$, and $a = 1{\cdot}57$ square inches, as compared with ·2474 square inch the real effective area.

The size of safety valves in use upon locomotives has probably been fixed without any regard to the requirements of the immense rate of evaporation in their boilers, as compared with that of stationary boilers. It would seem to be only the constant attendance upon locomotive engines, and the constant watch upon the steam gauge, that prevent the generation of steam faster than it could be delivered by the valve, and a consequent over-pressure.

V. The Transmission Apparatus, or that by which the power in the steam is transmitted to the engine, may be regarded as including the throttle valve; the steam-pipe, consisting of the dry pipe in the boiler, and the branch pipes; and that by which the steam escapes into the atmosphere after doing its work in the cylinder, or the exhaust pipes and blast orifice. The construction of the former is shown in Figs. 12—15, Plate B, of the drawings, and in Figs. 90 and 91, Plate C. If the boiler pressure is reduced, as it usually is, 20 lbs. from its pressure of 140 lbs., by this apparatus, its efficiency would be represented as $\frac{140 - 20}{140} = {\cdot}857$, and this is caused by and varies as the density of the steam, the square of the piston speed

and of the ratio of the area of the piston to the cross-section of the steam pipe, and depends upon the bends and friction in the pipes. The latter varies directly as the density and square of the velocity of the steam, and inversely as the diameter of the pipe. The motion of steam, or its efflux into a fluid of less density, or the atmosphere, depends upon the difference of pressure. The effective pressure, or the excess above the atmospheric only, acts to produce the motion of steam through the steam pipes, and its efflux into the cylinder. In doing this it can do work represented by $V w \times h$, where V is the volume of steam in cubic feet, w the weight of a cubic foot, and h the distance through which it moves, which may always be considered as a height through which the weight Vw falls. If there was no resistance to the motion, from the bends and friction in the pipes, in falling through the height h, from a state of rest, the weight of steam $W = Vw$, would acquire a theoretic velocity of v feet per second, and the energy thus stored in it would be represented, as we have already seen, by the fundamental term in dynamics,

$\frac{1}{2} Mv^2 = \frac{1}{2} \frac{W}{g} \cdot v^2$. Now if there is no loss, these two quantities of work are equal, or $\frac{1}{2} \frac{Vw}{g} \cdot v^2 = Ww \cdot h$, $h = \frac{v^2}{2g}$, and $v = \sqrt{2gh}$.[1] On this simple formula all the theory of the efflux of fluids is based, for the quantity, h, is the height of a column of steam one inch square, that would be equivalent in weight to the pressure of the steam per square inch above the atmosphere, or $\frac{p}{w} \times 144$.[II] Hence, to find the velocity with which steam of 100 lbs. effective pressure would escape into the atmosphere, we apply the formula

$v = C\sqrt{2gh} = C \times 8{\cdot}025 \sqrt{\frac{p}{w} \times 144}$. The pressure per square foot would be more exactly $100{\cdot}304 \times 144 = 14{,}443{\cdot}776$ lbs., the weight of a cubic foot of steam being at this pressure, ·26405 lbs., the velocity would be $v = C \times 8{\cdot}025 \sqrt{\frac{14{,}443{\cdot}78}{{\cdot}26405}} = C \times 1928$ feet per second. The mean value of the coefficient of efflux C, which, as shown by Weisbach, is made up and is the product of two other co-

[1] The formula is thus proved by Weisbach.

[II] D. K. Clark

efficients, a coefficient of velocity φ, and a coefficient of contraction a, may be taken at ·62. Hence, the velocity with which the steam would flow into the cylinder, when there is no back pressure above the atmosphere, would be $v = ·62 \times 1928^{\frac{1}{2}} = 1195$ feet per second. This velocity increases slowly with the pressure, and calculation shows how ample this immense velocity would be in the branch pipe, $4\frac{1}{2}$ inches in diameter, to keep up with any piston speed that can be produced in the locomotive. The resistance must be very great to reduce its velocity so that the pressure falls in the proportion stated. Probably the greater portion lies in the valve chest and steam passages, and from the wire-drawing of the steam by the valve. The disadvantageous custom of not fully opening the throttle valve when running, in the present practice of locomotive drivers, wire-draws the steam at the throttle valve, and greatly diminishes the efficiency of the transmission apparatus.

B. The Engine.—Having now ascertained the functions and mode of action, in one or two points, of the locomotive boiler, the consideration of the details of the mechanism lies before us. The remaining figures in the drawings, plates *A*, *B*, *C* and *D*, contain full details, it is believed, of every important part of this.

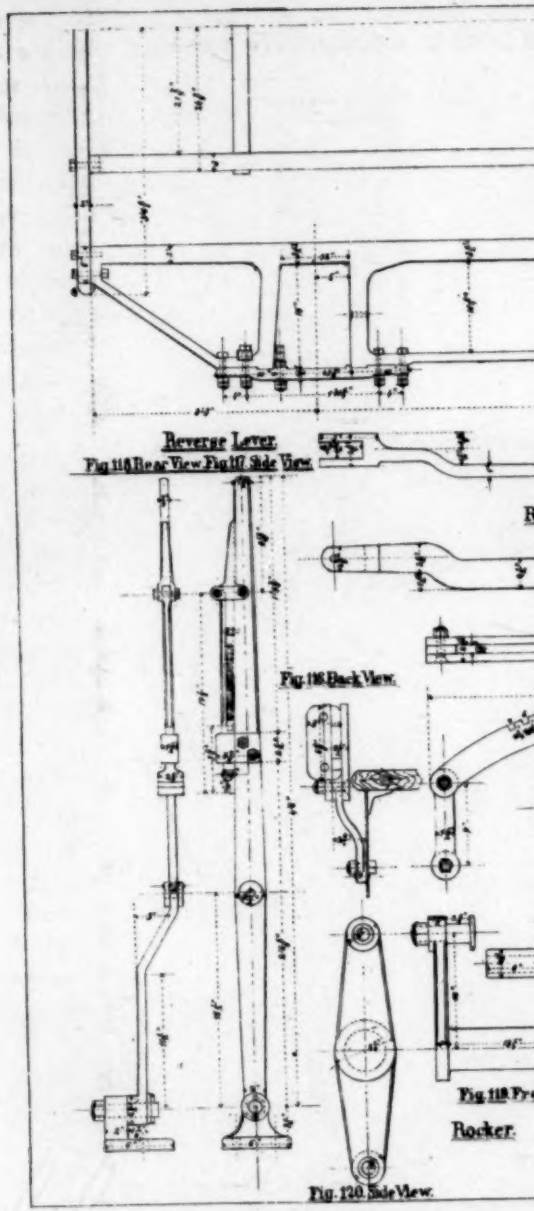
The fundamental ways by which a complete knowledge of the engine mechanism is to be found, are two.[ii] I. The action of the machine during parts of its period or cycle, by which we ascertain the laws which determine the internal efficiency of its parts; and II, its action during whole periods, or the relation between mean efforts and mean resistances, by which the actual efficiency is determined.

It will be necessary to here omit the discussion, by the first of these methods, of the engine mechanism in detail. Its treatment would involve a consideration equal to that of the boiler; but, useful and interesting as the field of inquiry thus opened is, the details of the mechanism are, by reason of their greater approach to perfection and efficiency, of secondary importance to those of the boiler, and do not require so careful a scrutiny.

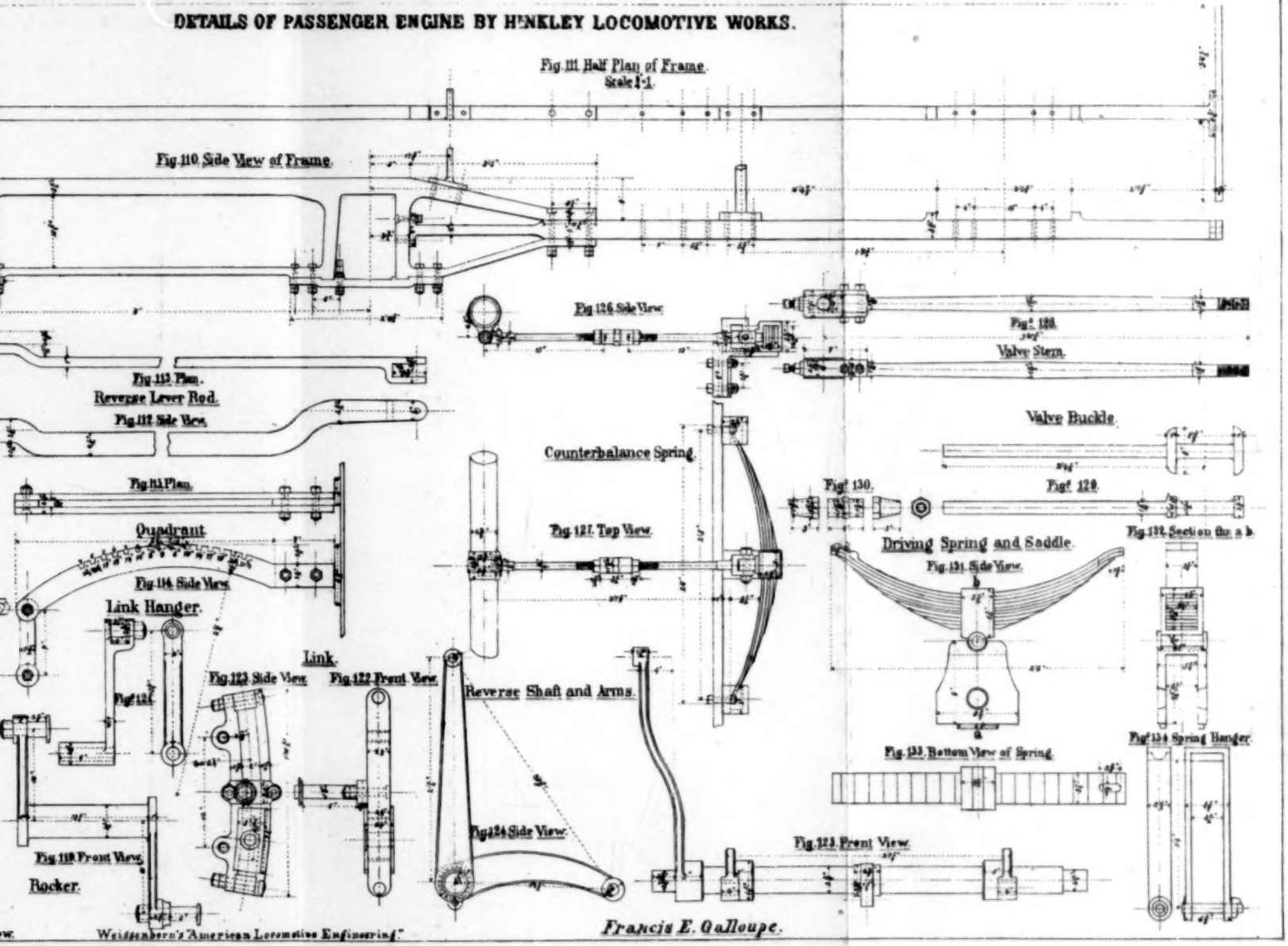
The second of these methods will form the method of inquiry in Part II, and I shall here merely state the topics which, in my imperfect plan of treatment, remain.

[i] Roper gives it 1875 feet, and D. K. Clark, 1957.

[ii] Rankine.



DETAILS OF PASSENGER ENGINE BY HENKLEY LOCOMOTIVE WORKS.



Weissenborn's "American Locomotive Engineering."

Francis E. Galloupe.

I. *In the Cylinder*, the description of position, construction and parts—its heads, piston, packing, casing, the valve face, steam-chest, steam and exhaust passages—would be followed by a discussion of the reasons for its particular dimensions; what has determined its proportion, and its relation to other parts, to the boiler and driving wheels, the boiler power, tractive power, and to the steam expended in it, and the friction in it, and methods by which it is diminished by lubrication.

II. There would next be the description, office, and geometrical construction of the *Valve Gear*, the slide valve, rods, rockers, links, hangers, eccentrics, their disks, straps and rods; and the Reverse Apparatus, whose parts are the quadrant, reverse lever, rod, lifting links and counterbalance spring. The slide valve, in a single simple piece of mechanism, fills the office of admitting, cutting off, and releasing the steam in the cylinder, and of regulating the power to be developed by the entire engine. The lead, lap and travel of the valve, as affected and determined by the construction of the link, its action, and illustration by means of motion curves form one of the most important and interesting topics, in the locomotive engine.

III. *In the Action of the Steam in the Cylinder*, the best mode of treatment would be the discussion of actual steam indicator diagrams, for which purpose some fine indicator cards have been obtained. By these could be found, the differences from the assumed theoretic diagram, and the actual condition of the steam in the cylinder, its pressure, mean pressure, real point of cut-off, as distinguished from its apparent, the curve of its expansion, its release and compression, and the real occurrences in respect to condensation. The action and theory of blast pressure, the advantages and disadvantages of each of the two methods of producing an artificial draught for the furnace, the vacuum and plenum, and the effect of the former upon back pressure and the effective power of the engine, would have to be considered here, in connection with the cylinder.

IV. *The Transmission of Power to the Wheels*, relates to parts, such as the piston, cross-head, connecting-rod, and crank. There would be in succession considered, the efficiency of the crank, as a means of converting reciprocating into circular or rotary motion; the effect of the angularity of the connecting-rod, over that produced if there was harmonic motion only; the weight of the reciprocating

parts, their accelerations and retardations during the stroke, and at the dead-points, and the efficiency of the combination.

V. *The Running Gear* includes the wheels, shafts, journals, and framing to which they are attached. The locomotive would here be regarded as a carriage or vehicle for the boiler and mechanism, and the action of the wheels upon the rails, and of centrifugal force, which is partially counteracted, upon curves by the tractive pull, pointed out.

VI. *In the Balancing of the Engine*, would be considered the manner in which the weight is supported upon three points or a tripod, the driving wheels and centre pin of the truck, by means of the springs and equalizing levers; the means for preventing the zig-zag or lateral tendency of the motion to cause the flanges of the wheels to grind against the rails, arising from the alternate maximum force of the pressure upon the pistons upon each side of the engine; how this is affected by the gauge of the road; and how the weight of the reciprocating parts is balanced in the driving wheels.

All these relate to the engine alone, and doubtless other points would suggest themselves in the treatment of these.

VII. *The Tractive Power and Train Resistance* will be briefly considered in the following part.

Part II.—Trial of an American Passenger Locomotive.

By the kindness of Mr. Jno. Thompson, Master of Machinery of the Eastern Railroad Company, the opportunity was obtained of riding upon the engines of two of the fastest passenger trains of that road, and of taking therefrom data concerning the actual running of locomotives. The trains selected were the 2.15 P. M. Rockport train from Boston, which runs for a distance of 36 miles, and after a stop of 55 minutes at the terminus, makes a return trip to Boston; and the Bangor Express train, which leaves Boston at 8.30 A. M. The engine of this train runs to Portsmouth, N. H., 56 miles from Boston, is there detached, and 18 minutes after, with another train, makes a return trip to Boston. After obtaining information concerning the running of these engines, on Tuesday afternoon, March 14th, engine No. 36, "The John Howe," was taken, in order to

TABLE I.—Trip No. 1.

DATA AND RESULTS FROM HINKLEY ENGINE, No. 55, EASTERN R. R., ON 8.30 A. M. BANGOR TRAIN, DOWN TRIP.

Date: Wednesday, March 15th, 1876.
Day: Weather, dry and chilly; Temperature, 15°—40° Fah.; Wind, W., and very strong.

At Boston: Coal in Tender at starting, 15 tubs, at 400 lbs., = 6000 lbs. Depth Water in Tender at starting, about 42 inches. Number of Cars, 5 Passenger, 1 Pullman, 1 Baggage, 1 Postal; Total, 8.

1	2	3	4			5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.				Steam Pressure. Gauge Readings.	Coal Record.			Speed Record.						Water and Steam Record.		
Miles from Boston.	Train Due. Time.	Station. Leave	Train Arrivals and Leavings. Corrected time by watch.			Length of Stop.		Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake, Pressure, etc.
	H.	M.	H.	M.	S.	M. S.	Lbs.	Lbs.	Lbs.			Lbs.						Lbs.	
	A	M	A. M.																
	8	30	Boston	8	30	34	137	13·5	13·5								2·079		Watch practically correct with railroad time, at 8.30 A.M.
				ar.	33	15	.....				.....	.....	.....	.....	.....				
			Prison Point	8	33	20	.....	81·0	94·5		14					15·1	12·474	454·1	
				....	..	...	5												
			B. & M. R. R. Crossing	8	35	40	...	138											
2			Somerville	8	37	05	.....	27·0	121·5		21½ 20½						4·158		
			Curve at Somerville	8	38	30	.....	67·0	189·0	61	19 17	.....	.....	.....	.....	26·6	10·395	907·9	
											14								
3			Everett	8	40	45		124	40·5	229·5	68	10					6·237		
				ar.	43	50	.....				.....	.....	.....	.....	.....	38·7		194·6	
5	8	42	Chelsea	8	44	15	25	139	101·3	330·8	20	10					15·600		Took 50 seconds to stop after brake was put on.
6			Revere	8	48	30		130	67·5	398·3	101	.....	.....	.....	.....	14·1	10·395	973·4	Oiled cylinders from cab.
												.....	.....	.....	.....				
			Oak Island	8	51	50		115	141·8	540·1		10				32·4	21·837	502·8	{ Reading of Westinghouse Air Brake Gauge, 100 lbs.
10			West Lynn	8	55	55†		114	13·5	553·6	53	.....	.....	.....	.....		2·079		
				ar.	57	20†	.....				.....	.....	.....	.....	.....	42·3†			
11	8	59	Lynn	9	0	30	3 10	134	13·5	688·6	14	10					20·790	129·7	Engine clock 50 seconds slow, by watch.
												.....	.....	.....	.....	16·7		1297·3	
12			Swampscott	9	04	05		123½	94·5	783·1	135						14·553		Throttle one-half open.
				ar.	10	50	.....	126				.....	.....	.....	.....	35·6		227·0	Oiled cylinders.
16	9	12	Salem	9	13	15	2 25	133	81·0	864·1	27						12·474		
			Know-nothing	9	15	10		118										389·2	
				ar.	20	15	.....				.....	.....	.....	.....	.....	17·1			
18	9	26	Beverly	9	20	50	35	127	148 5	1012·6	41	10					62·869	1961·5	{ Very heavy up-grade, 43 ft. to one mile. Oiled cylinders.
				ar.	27	45	.....				.....	.....	.....	.....	.....				
20	9	28	*North Beverly	9	28	05	20	130	94·5	1107·1	74	14	125	150	2454	27·9	17·3	14·553	453·5
				ar.	32	45	.....				.....	.....	.....	.....	.....				At 9.32 reverse lever was put in full forward gear, 10 secs. later the brake was put on, and full stop was made at 9.32.45.
22	9	32	Wenham	9	33	25	40	123	216·0	1323·1	48	10	123	160	2618	29·8	25·1	33·264	415·2
				....	...	...		122											
27	9	43	Ipswich	9	46	25	...	137½	94·5	1417·6		10	123	192	3141	35·7	.....	5·387	112·1
												10					21 6		Safety valve blowing. Throttle one-half open. Took in water.
30	9	50	*Rowley	9	54	45		114	128·3	1545·9	32	10	114	240	3927	44·6		7·313	Depth before filling, 16 in.; after filling, 41½ in.
												10					27·7		
34			*Knight's Crossing	10	3	25		.....	102·0	1707·9	32	10	110	150	2454	27·9		9·234	114·1 Speed taken at bridge.
				....	...	...		.....									16·9		
			Know-nothing	10	12	20	...	.....				.....	.....	.....	.....	.....			
				....	...	...		.....										192·1	
37	10	05	Newberryport	10	14	00	...	148	121·5	1829·4	54	.....					22·5	6·926	Valve blowing. Oiled cylinders.
												10	124	192	3141	35·7	.....		
39			*Salisbury	....	...	...		.....				10							
				....	...	...		.....				.....	.....	.....	.....	.....	.....		
42	10	20	*Seabrook	10	25	05		132	81·0	1910·4	24	10							86·4
												.....	.....	.....	.....	.....	14·1	4·617	
43	10	25	*Hampton Falls	10	29	20		136	175·5	2085·9	81								288·1
				...	...	...		.....				.....	.....	.....	.....	.....	24·5	10·004	208·1
46	10	33	Hampton	10	36	40	...	120	216·0	2301·9	59								
				....	...	...		.....				.....	.....	.....	.....	.....	24·8	12 312	256·1
49	10	40	North Hampton	10	43	55	...	110	189·0	2490·9	72	14						10·773	{ Heavy up-grade, about 43 feet to 1 mile.
												14	103	140	2290	26·0	17·1		356·1
51	10	47	*Greenland	10	50	55		120	243·0	2733·9	95	10						13·851	Heavy up-grade. Pressure in air brake receiver fell from 76 lbs. to 40 lbs. in stopping the train, with the brake pumping. Stirred fire six times after leaving Boston.
									Tot. for 56 miles run.										172.8
			Arrive at																
56	10	57	Portsmouth	11	01	00		125			49	10	111	200	3273	37·2	29·8		{ Depth water in tender before filling, 31¼ in.
												10	111	230	3600	40·9			{ Depth water in tender after filling, 40¾ in.
			Average steam pressure, 127 lb.						Av. lb. coal per mile,		56					Average,	23·5	Average,	460·5

* Flag Stations.

† Time doubtful.

TABLE II.—Trip No. 2.

DATA AND RESULTS FROM HINKLEY ENGINE No. 55, EASTERN R R., ON BANGOR TRAIN, RETURN TRIP.

Date: Wednesday, March 15th, 1876.
Day: Weather, dry and chilly; Temperature 15°—10° Fahr.; Wind, W., and very strong.

At Portsmouth: Coal taken on, ...; Depth Water in Tender at starting, 40¾ inches; Number of Cars, 7.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.			Coal Record.			Speed Record.						Water and Steam Record.		
Miles from Portsmouth.	Train Due. Time.	Station.	Train Arrivals and Leavings. Corrected time by watch.	Length of Stop.	Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Notes. Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	H. M.	Leave	H. M. S.	M. S.	LBS.	LBS.	LBS.			LBS.						LBS.	
	A. M.		A. M.														
	11 18	Portsmouth	11 26 35		137	81·0†	364·5		14						30·731		†Six shovelfuls, or 81 lbs. of coal were put in before leaving Portsmouth. Coal wet before starting.
						283·5			10	95	160	2518	29·8	22·5		495·8	
5	11 28	*Greenland	11 39 55		94	141·8	506·3	73	10	93	180	2945	33·5		15·456		Stirred fire.
														17·3		482·2	
7	11 35	North Hampton	11 46 50	...	94	135·0	641·3	71							14·715		
									10	114	200	3273	37·2	30·0		306·1	Oiled cylinders. Stirred fire.
10	11 42	Hampton	11 52 50	...	127	54·0	695·3	45	10						5·886		
														37·9		122·4	
13	11 47	*Hampton Falls	11 57 35		128	148·5	843·8	18							16·187		
			P. M.											12·0		1010·1	
14	11 50	*Seabrook	12 02 35		128	175·5	1019·3	149	10	119	130†	2127	24·2		19·130		†Heavy up-grade.
									10	104	240†	3927	44·6	28·8		397·9	†Up-grade. Air brake pressure fell from 85 to 50 lbs. in stopping the train.
17	P. M.	*Salisbury	12 08 50			40·5	1059·8	59	10	102	220	3600	40·9		4·415		
			ar. 12 50											30·0		137·7	Stirred fire.
19	12 05	Newburyport	12 14 50	2 00	133	94·5	1154·3	20							10·361		
		Know-nothing				108·0	1262·3							14·2	21·772	667·1	
22		*Knight's Crossing	12 27 30		117	148·5	1410·8	68	10						16·187		
									10	110	220	3600	40·9			252·6	Oiled cylinders.
26		*Rowley	12 ... 05		122	2·9·5	1640·3	37							25·016		
			ar. 34 15		118											520·3	Stir'd fire. Safe. valve began to blow off at 142 lb.
29	12 28	Ipswich	12 40 40	6 25	134	195·8	1836·1	77	10						30·741		At Ipswich, } before filling, 17¼ in.
									10	97	150	2454	27·9	25·7		383·7	Depth water in tender, } after filling, 42 in.
34	12 40	Wenham	12 52 20	...	103	54·0	1890·1	30	10						8·478		Stirred fire.
									10	102	170	2781	31·6	27·7		264·5	Up-grade.
36		*North Beverly	12 56 40		98	67·5	1957·6	27	10						10·598		
									10	100	220	3600	40·9	25·7		330·1	Oiled cylinders.
38	12 48	Beverly	1 01 20	...	118	54·5	2011·6	34							8·557		
		Know-nothing				40·5	2052·1							19·1	6·359	465·4	Stirred fire.
			ar. 07 35		124												
40	12 58	Salem	1 09 00	1 25	143†	216·0	2268·1	128	10						33·912		† Valve blowing.
														31·3			
44		Swampscott	1 16 40		99	00·0		54	10							423·1	
			ar. 19 15		118				10	98	200	3273	37·2	23·2			
45	1 11	Lynn	1 20 00	45	128	40·5	2308·6	00							6·359		Oiled cylinders.
														12·7		396·8	
46		West Lynn	1 23 25		114	114·8	2423·4	41	10						18·024		
																	Stirred fire.
		Oak Island	1 27 30		98	00·0			10					30·5		281·1	
50		Revere	1 31 15		98	67·5	2490·9	29	10						10·598		
			ar. 35 15											12·9		661·3	
51	1 28	Chelsea	1 35 55	40	113	40·5	2531·4	68							6·359		
														32·7		192·4	
53		Everett	1 39 35		104	13·5	2544·9	20							2·120		
		Curve at Somerville	1 41 55		100	00·0								14·7		132·3	
			ar. 43 40														Stirred fire.
54		Somerville	1 44 00	20	101	27·0	2571·9	14							4·239		
		B. & M. R. R. Crossing					Tot. for 56 miles run.										
		Prison Point	1 46 35	...	110									22·8		132·3	
																	Took 35 seconds to stop at Boston.
		Arrive at															Depth water in tender on arrival, 23¾ inches.
56	1 45	Boston	1 49 15		110												Watch 15 secs. fast by standard time at 1.55 P.M.
			Average steam pressure, 115lb.			Av. lb. coal per mile,		55					Average,	23·6	Average,	383·6	

*Flag Stations.

TABLE III.—Trip No. 3.

DATA AND RESULTS FROM HINKLEY ENGINE, No. 55, EASTERN R. R., ON 8.30 A. M. BANGOR TRAIN, DOWN TRIP.

Date: Thursday, March 16th, 1876.
Day: Weather, dry and pleasant; Temperature, 40° Fah.; Wind, W., breeze.

At Boston: Coal in Tender at starting, 14 tubs, at 400 lbs., = 5600 lbs. Depth Water in Tender at starting, about 40 inches. Number of Cars, 5 Passenger, 1 Pullman, 1 Baggage, 1 Postal; Total, 8.

1	2	3	4			5		6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.						Coal Record.			Speed Record.						Water and Steam Record.		
Miles from Boston.	Train Due. Time.	Station.	Train Arrivals and Leavings. Corrected time by watch.			Length of Stop.		Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Notes.
	H. M.	Leave	H.	M.	S.	M.	S.	Lbs.	Lbs.	Lbs.			Lbs.						Lbs.	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	A. M		A. M.																	
	8 30	Boston	8	31	00			132	00·0	00·0		10								Watch practically correct at 9.30 A.M. Oiled cylinders.
		Prison Point	8	33	40		...	131	40·5	40·5		21⅛					17·8	0·845	213·5	
		B. & M. R. R. Crossing	8	36	15		...	130	00·0	40·5		10								
2		Somerville	8	34	45			123	27·0	67·5								4·563		
		Curve at Somerville	8	39	00			122	81·0	148·5	34						17·1	13·689	1138·9	
3		Everett	8	41	15			119	40·5	189·0	81	10	118	200	3273	37·2		0·845		
5	8 42	Chelsea	8	44	30		..	132	94·5	283·5	20	21⅛	127	180	2945	33·5	36·7	15·971	213·5	Stirred fire.
6		Revere	8	48	55			127	94·5	378·0	95	10		160	2618	29·8†	13·6	15·971	996·6	† Taken at 8.47.25, and counted till 48.55.
		Oak Island	8	51	50			126	81·0	459·0		10		200	3273	37·2†	32·7	13·689	462·7	† At 51.00.
10		West Lynn	8	56	15			128	00·0	459·0	44	10	127	220	3600	40·9†				† At 54.00
			ar.	58	25			138†					128	120	1963	24·1†				† At curve, 54.45.
11	8 59	Lynn	9	00	00	1	35	139	47·3	506·3	00	14					27·7	7·994		† Valve blowing off. Stirred fire. Damper open in fire-box door.
12		Swampscott	9	03	45			128	94·5	600·8	47	10		160	2618	29·8	16·0	15·971	498·8	Oiled cylinders.
			ar.	10	15			134				10	127	220	3600	40·9†	36·7		249·0	† Time, at 9.06.00.
16	9 12	Salem	9	13	00	2	45	133†	67·5	668·3	24	6	125	240	3927	44·0†		11·408		† Valve stopped blowing off. † Time, at 9.07.15.
			ar.	15	50			135				21⅛								
		Know-nothing	9	16	15		25	136				14					15·8		355·9	
			ar.	20	35			138†				10	128	140	2290	26·0†				† Time, 9.18. Stirred fire.
18	9 26	Beverly	9	21	15		40	136†	67·5	735·8	34	10						11·408		† Valve blowing.
20	9 26	*North Beverly	9	27	55			134	54·0	789·8	·4	10	133	160	2618	29·8†	18·0		355·9	† Heavy up-grade. Time, 9.23.00.
												10	132	150	2454	27·9†		9·126		† Time, 24.20.
22	9 32	Wenham	9	33	10		...	137†	135·0	924·8	27	10	129	80	1309	14·9†	22·8		284·7	† Level. Time, 26.00. Stirred fire.
			ar.	42	40							6	126	180	2945	33·5†		22·815		† Valve blowing. † Time, 9.30.00. Stirred fire.
27	9 43	Ipswich	9	46	05	3	25	135	162·0	1086·8	27	6	128	260	4255	48·4†	31·6		284·7	† Time, 9.38.00 Took on water. [after, 42¾ in.
												6	124	230	3764	42·8†		20 088		† Time, 9.41.00. Depth before filling, 20 in.;
30	9 50	*Rowley	9	53	10			130	121·5	1208·3	54	10	123	240	3927	44·6†	25·3		417·8	† Time, 9.49.00.
												10	12›	240	3927	44·6†		15·066		† Time, 9.50.00. Stirred fire.
34		*Knight's Crossing	9	59	50			120	54·0	1262·3	30	10	126	190	3108	35·3†	36·0		235·1	† Up-grade. Time, 9.56.00.
												10	124	204	3338	37·9†		6·696		† Time, 9.58.00.
		Know-nothing	10	03	10		...	133	67·5	1329·8		10	119	220	3600	40·9†				† Time, 10.01.00.
												10					17·8	8·370	313·2	Oiled cylinders.
37	10 05	Newburyport	10	09	55		...	141	54·0	1383·8	41	14						6·695		At Newburyport, depth water in tender, 36 in.
												10	120	200	3273	37·2†	25·7		268·9	† Time, 10.13.00. Stirred fire.
39		*Salisbury	10	14	35			124	135·0	1518·8	27	10						16·740		
42	10 20	*Seabrook	10	20	55			123	40·5	1559·3	45	10	121	190	3108	35·3†	28·3		348·2	† Time, 10.16.00.
												10	124	180	2945	33·5†		5·022		† Up-grade. Time, 18.00.
43	10 25	*Hampton Falls	10	25	05			122	67·5	1626·8	41	10	122	160	2618	29·8†	14·4		313·4	† Time, 10 23.00. Stirred fire. No stop made.
			ar.	30	25			135†										8·370		
46	10 33	Hampton	10	33	10	2	55	138	27·0	1653·8	23	10	117	120	1963	24·1†	33·6		174·1	† Very heavy up-grade. Time, 10.27.00.
			ar.	39	25							14						3·348		† Valve began to blow off at 144½ lbs., while at
																	24·8		69·6	Stirred fire. [station.
49	10 40	North Hampton	10	40	25	1	00	138	40·5	1694·3	9	10						5·022		Stirred fire.
			ar	47	10							10	138	150	2552	29·0†	16·9		156·7	† Up-grade. Time, 10.42.30
51	10 47	*Greenland	10	47	30	2	.....		229·5	1923·8	20	10	120	160	2618	29·8†		28·458		† Time, 10.49.00. Stirred fire.
										Tot. for 56 miles run.										
		Arrive at																		
56	10 57	Portsmouth	10	57	45			118			46	10	118	220	3600	40·9†	29·3		355·1	† Time, 10.50.00. Stirred fire. [from full speed.
												10	110	240	3927	44·6†				Up-grade. † Time, 10 52.00. Took 40 secs. to stop
		Average steam pressure, 131 lb.							Av. lb. coal per mile,		41					Average,	24·5	Average,	364·1	Depth water in tender { before filling, 27 in. after filling, 42 in.

* Flag Stations.

become practically acquainted with the daily operation of the locomotive.

After setting my watch carefully by the railroad time, making out a table with blank columns for data, measuring the diameter of the driving wheels and pump plunger, taking the depth of water in the tender, obtaining an estimate of the amount of coal aboard, and the capacity of the tank, and noting the weather, condition of the rails, direction of the wind, the steam gauge, the numbers on the cut-off notches of the reverse quadrant, and the number of cars, we started. Mounted upon the fireman's seat, the engine rode much easier than was expected, and, except at the greater speeds, little difficulty was experienced in writing.

At the higher speeds even, from five to six revolutions, or ninety-eight feet per second,—the momentum of the engine carried it lightly over the slight inequalities in the rails, and it was very rarely that much thumping or pounding occurred.

Upon the three succeeding days, trips were made to Portsmouth and return upon engine No. 55, which was built at the Hinkley Works in October, 1875, and is the same engine the details of which have been given, and parts discussed in Part I.

Upon these trips records of the time were taken, as accurately as possible, at which the engine passed each station, of the steam pressure, the cut-off notch, and the amount of coal thrown into the fire-box, and although the stations came rather close together in respect to time, when not employed in any other direction, the speed was usually taken by counting the oscillations of the cross-head.

In brief, the aim was to jot down every occurrence that took place in regard to the engine.

The accompanying tables show the data taken, and the results obtained.

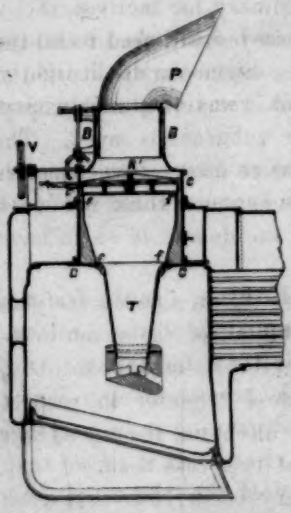
The carrying of a train from Boston to Portsmouth means so many gallons of water and pounds of coal consumed. These tables state approximately what these amounts are. They show, so far as no exceptional conditions exist, primarily, the facts concerning the actual manner in which the best locomotives are at the present time run. From these data are furnished us the means whereby we may calculate other circumstances in regard to locomotive power and resistances, which have their influence in determining its actual efficiency.

(To be continued.)

CONSUMING SMOKE IN FURNACE OF LOCOMOTIVE ENGINE.

[From the *Engineer*, London, Dec. 15th, 1876.]

We illustrate in the accompanying engraving a very curious arrangement for consuming smoke in locomotives, used with great success on the Constantinople and Adrianople section of the railways of European Turkey. The device has been patented by Herr v. Reimherr, locomotive superintendent of the line; it will be seen at a glance that a wind-cowl directs a strong current, when the engine is running, on the fire. The apparatus is characterized by the two following features:—Natural injection, the progressive motion of the locomotive, occasioning a certain quantity of hot air to spread evenly over the fire. Introduction of an iron plate cylinder between the crown of the fire-box and the outer shell of the boiler, which relieves the crown-plate of about one-third of the pressure which it generally bears. The manner in which the smoke-consumer, constructed according to those principles, may be applied to a new, as well as to already existing locomotives, will be easily understood from the adjoined drawings and the following description:—*c c* is the iron plate cylinder which unites the fire-box-crown with the boiler-shell, and relieves the former of a part of the pressure; this cylinder is open at top and bottom; *f f*, cast iron cylindro-conical tube placed inside of cylinder *c c;* the empty space round these two is to be filled with fire-clay, to prevent the cooling of cylinder *c c; T*, conical cast iron tube, resting with its upper flange on the lower bearing of tube *f f;* an air distributor, made of fire-clay, is fixed to lower end of the conical tube *T; R'* is a register valve for regulating the admission of cold air; *B*, cast iron mantle; *P*, bell-mouthed air catcher, which can be turned and fixed in all positions by a gearing of tooth-wheels and bevel-wheels worked by the small hand-wheel *V*. The self-progressive motion of the locomotive forces the air into the air-catcher *P*, whose mouth must always be turned in the direction of the motion of the engine. The air, heated by its



contact with the cylindro-conical tube *f f* and the cone *T*, escapes through the channels in the fire-clay air-distributor, being evenly dispersed over the surface of the burning fuel, and at a sufficiently elevated temperature to produce a complete combustion.

The apparatus has been fitted to a six-wheeled all coupled goods engine, weighing thirty-six tons. The wheels are all between the fire-box and the smoke-box. The fuel used is Cardiff and Newcastle coal mixed, and the consumption on passenger trains equaled 11 to 12 kilos. per millimetre. The apparatus has been at work since May, and saves a large proportion of fuel, besides completely preventing smoke. Between Constantinople and Adrianople the country rises twice, necessitating inclines of 1 in 60; ordinary locomotives, therefore, have to work hard, and the increased draft used to fill the smoke-box with unburned particles of coal. Since the application of Herr Reimherr's apparatus the smoke-box remains almost empty, and all the coal formerly carried into it unburned is saved. The trains do not go faster than about 18 miles an hour; it is therefore supposed that the apparatus with express engines would act much more vigorously.

Cost of Railway Improvements in Europe.—In the *Builder*, London, November 18, 1876, there is a compilation of the directors' reports of expenditures on the Midland Railway, for the period of five years, ending June last, which shows the process of aggregation of capital in conjunction with a thriving and growing railway system *after the completion* of the main stem of the lines. It is shown that, in their original construction, the capacity of the "lines open for traffic" was very far short of the actual requirements for traffic purposes; and in further land purchases, duplicating lines, making new sidings, extending the station and warehouse accommodation, and generally improving the carrying capacity of the line, an enormous amount has been expended, the lines having been only gradually brought up to their present state of efficiency. The gross outlay under this head, has been for land, compensation, construction of way and stations, £5,100,000; for Law and Parliamentary charges, £133,000; for Block Telegraph, £37,000, making a total of £5,270,000. The additions made in this way to the original cost have been at the rate of about £1,050,000 per annum, or on the mean "open" mileage not less than £5,000 per mile in the period of five years. In other words, the property has been, in five years, improved at a cost almost equiv-

alent to the construction of an additional single line throughout the entire system. On referring to the last issued report, we find also the expenditure of this character is by no means exhausted, for in the current half year, £821,000 were to be laid out in providing increased station accommodations, sidings, engine sheds, work-shops, etc., on the lines already open for traffic; and even afterwards the known necessities of the lines would take £849,000 further to meet them. The whole of this additional outlay has already received the sanction of the proprietors.

It is shown also under the head of the expenditure upon the construction of new lines, that spread over a lengthened period, and embracing a vast number of new lines variously situated, this branch of the expenditure throws some light on the relative cost of (1) land, and compensation paid for property taken over by the company; (2) the construction of the lines, including structures, signals, rails, etc.; and (3) the by no means inconsiderable amount represented by legal and Parliamentary costs, including conveyancing, etc. The proportion of the cost attributable to each of these distinct heads would appear to be:

Land and compensation, ...	11 per cent.
Construction, including rails, etc., . .	88 "
Law and Parliamentary, ...	1 "
	100

The gross outlay under this head, it would appear, has been £4,892,000, for which about 200 miles of new line have been added to the Midland system, the cost being equal to about £25,000 per mile. The further expenditure under this head will be no less than £3,500,000, to complete the 122 miles wholly, and 49 miles partly, owned by the company, and still under construction or to be constructed.

The further heads of expenditure during the five years comprise £2,336,000 for new rolling stock, and a similar amount subscribed to other connecting lines in which the Midland company is interested. For the latter object £1,000,000 further will be subscribed in the current and future half years.

It will thus be seen that the company has been laying out £3,000,000 per year for some years back, and we may believe that it has been judiciously applied, judging from the high dividend position the company has been able to maintain concurrent with this enormous expenditure.

THE LATEST ARMOR PLATE EXPERIMENTS AT SPEZIA.

[From the *Iron Age*, New York, February 8th, 1877.]

A recent number of the London *Times* has an interesting account of some of the Italian experiments at Spezia, conducted during the month of December. The experiments at Spezia were temporarily suspended, because some of the targets had not arrived. The series has since been continued and brought to an end by the complete destruction one after another of all targets opposed to the 100 ton gun. This was only to be expected after the proofs given during the earlier trials that gun and carriage were more than equal to the task set before them. But the latter series of experiments has been so interesting on account of the variety of the targets and the use of reduced charges in some cases, that we are glad to have the opportunity of presenting the results to our readers.

It will be remembered that during the first series 42 rounds had been fired with various charges, but all exceeding the guarantee of the manufacturers, and that, in some cases, the guarantee was so overpassed that the Italian government declared themselves satisfied, and accepted the gun, so that they might make the best use of the experiments, by trying different charges of different kinds of powder. The powder used throughout the second series, was that manufactured expressly by the Italians, and called "progressive powder of Fossano." The result has been highly satisfactory to the scientific designers of the powder, for, though a considerable quantity of it has to be used to give a certain velocity, high velocities can be obtained with a very moderate pressure on the interior of the gun. The manufacture of the Fossano powder is peculiar. After passing through the first stages of manufacture, and being brought to the condition of "meal powder," it is pressed into cakes, which have a density of 1·79. The cake is then broken up into irregular grains of about $\frac{1}{8}$ to $\frac{1}{4}$ in. in thickness. The grains are then mixed with a certain quantity of fine grain powder, and the whole mass is pressed into a cake which has a density of 1·776. This second cake is then broken up into tolerably regular pieces, about $2\frac{1}{8}$ in. square by $1\frac{3}{4}$ in. thick. These grains, if they can so be called, are therefore composed of a number of small pieces with a higher density, placed like

the raisins in a plum-pudding, in a sort of conglomerated powder material of a lower density. The intention of the inventors of this powder was to bring about a condition of affairs in which more gas would be produced in a given time when the powder has been partly burnt, than at the commencement of its ignition.

On the 14th of December, the first round of the new series or 43d round from the 100 ton gun was fired with a charge of 240 lbs. of Fossano progressive powder, and the usual 2000 lb. Palliser shell against the Cammell sandwich target, which presents a front 12 in. plate, then 12 in. of wood, with iron stringers, and behind that a 10 in. plate. This charge was a very small one, and gave a velocity of only 1050 feet per second. The object of the committee was to find the actual penetration of different forms of targets, under conditions which would prevent the complete penetration of the structure, for the previous experiment had shown that to fire the full charges would in every case be the ruin of the target and prevent anything like judgment of comparative results as far as penetration was concerned. The shell passed through the first plate and cracked it through from top to bottom, passed through the wooden interior, and entered 6·8 in. into the second plate. The base of the shell broke up and the remainder was starred. Judging from past experiments with gun cotton shells, the Italian committee consider that had this shell been loaded it would have completely blown off the front plate. As it was, the skin of the ship was cracked and a vertical iron beam behind was considerably doubled up.

The gun was then loaded for the 44th round, the charge and projectile being precisely similar to those used in the preceding round. This time the target was of the same dimensions as that used in the old experiments, but with a Brown's solid plate 22 in. thick. The sea was rough, and the pontoon moved visibly after the gun was laid, so that the shell, instead of striking the point aimed at, hit the plate on its lower edge and broke into several pieces, which were deflected downward and made a hole in the ground about 6 ft. or 8 ft. deep in a slanting direction under the target. Though lost for the immediate object of the experiment, this round was of great interest, for it showed that a shell striking the edge of the narrow belt of armor, which will soon be all that ships can afford to carry, will tear through the bottom of the vessel with force enough to pierce engine-rooms and boilers, and pass out below the water line on the other side.

Round 45 had been looked forward to with great interest. Previous experiments with guns of smaller calibre had given reason to believe that a plate of chilled cast iron, by presenting an extremely hard surface to the point of the projectile, might break it and so prevent its penetration. The charge was 400 lbs. of Fossano powder, and gave a velocity of 1494 ft. to the 2000 lb. shell, just equal to the effect of a charge of 341 lbs. English powder. The target had 8 in. plate in front, then a strong layer of wood, and behind this a 14 in. plate of chilled iron from the Gregorini Works, near Como.

This Gregorini cast iron deserves a word of praise. It is really of splendid quality, being very hard, with a tensile strength of from 16 to 17 tons per inch. Ordinary cast iron usually fails at about half that strain, and very rarely rises as high as 10 or 12 tons. Indeed, so good is it that the Italian artillery of the land service have succeeded in producing heavy cast iron rifled guns far superior in strength to anything that has ever been known in England. But it was not able to resist the shell from the 100 ton gun, which penetrated the target completely and caused a more terrible ruin behind than had occurred in any previous experiment. The shell was broken up into many pieces, which dashed through into the interior of the ship, carrying with them a great number of ragged fragments of broken plate, and causing such a hail of iron that nothing could have lived between decks. The sand bags behind were deeply pitted with many hundreds of pieces, and the experiment clearly proved that the old fault of cast metal still exists, namely, that when it breaks under the influence of a heavy blow, it is dashed to atoms.

In round 46 the shell broke up in the gun, but round 47 was fired under the same conditions as No. 45, and the iron plates were similar in kind and dimensions—only in this case the front wrought iron plate was placed immediately upon the cast iron in rear; the wood coming behind both; again the target was completely penetrated and ruined, a large portion of the front plate being at the same time torn off. In these two remarkable rounds (45 and 47) not only were the fragments of the cast iron plate driven forward, but also out of the sides of the targets. Again, nothing could have lived behind the target, so terrible was the hail of iron fragments caused in round 47, the velocity of the shot being 1502 ft.

After the failure of striking the right spot, which occurred in round 44, on account of the motion of the pontoon, and therefore of

the gun, the apparatus for firing was transferred to the deck of the pontoon, and an arrangement made by which the officer, whose duty it was to touch the button which, by the action of electricity, carried flame to the powder, could himself run the piece and discharge it at the right moment. This was a near approach to what would actually happen on board ship, and the result was, that in every succeeding round the white mark painted on the target, was obliterated by the shot, which always struck on the right place.

The combinations of iron and wood, wherein the iron was in two layers, having thus been destroyed, the target carrying the 22 in. solid Brown's plate was again subjected to attack. Round 48 was fired with a reduced charge of 240 lbs., similar to that used in round 43. The velocity was 1062 ft., and the point aimed at was near the left of the target. The shell broke up the front part, remaining in the hole, having penetrated about 15·6 in. If we compare this effect with round 43 against the sandwich target, we shall see that the solid Brown's plate had by far the best of it; for while the projectile fired at the sandwich target with a velocity of 1050 ft. penetrated nearly 31 in., of which 19 in. was through iron, that fired at the Brown's plate penetrated only 15·6 in. of iron and no wood. Taken in conjunction with the possible use of gun cotton shells, this round would appear to establish conclusively the fact, that targets composed of moderately thick iron plates, placed in layers alternating with wood, such as that now under trial at Shoeburyness, do not all approach in strength the same thickness of iron disposed in one solid plate on the front of the structure. Round 49 was fired with 180 kilog. (400 lbs.) of progressive powder, representing what is for the present the full service charge of the 100 ton gun. The velocity of the projectile was 1499 ft., and it was aimed at a part of the target near the right of the plate. A large portion of the plate was torn off, the target was completely penetrated, and the rear of it so ruined as to be incapable of repair; but the hail of fragments behind was not so terrible as in the case of the target backed by cast iron.

The gun was loaded for round No. 50, but with a charge calculated just to penetrate the Brown's solid plates—namely, 264 lbs. of English powder. The velocity given to the projectile was 1299 ft., and it was aimed full in the centre of the Brown's plate. The effect was as anticipated. The shell just passed through the plate, of which it tore off a large fragment, splitting the plate from top to bottom. The

backing was not pierced. The verdict of every one was that Brown's wrought iron plate had proved itself to be of magnificent quality, as it gave a high resistance to penetration with a minimum of brittleness, but it could not be expected to keep out a 2000 lbs. shell, fired with a velocity of 1500 ft.

The Working of the Mississippi Jetties.—New Orleans papers continue to bring evidence of the success of Captain Eads' engineering in the mouth of the Mississippi. The *Picayune* says: We learn, that for some time past the channel between the jetties at the South Pass is everywhere more than 200 feet wide, for a depth of 20 feet at average flood tide, and that in the middle of this wide channel the depth is more than 22 feet. This is equal to from 22½ to 23 feet at the highest tide at South Pass, when a range of three feet tide, with a channel depth of 19½ feet, for from 80 to 100 feet in width, is usually reported at Southwest Pass. Therefore it will be seen that the jetties have given, though yet in an incomplete state, a magnificent channel across the South Pass bar to sea, twice as wide and several feet deeper than has ever been obtained across the Southwest Pass bar. All through South Pass, from its head to the jettied channel over the bar, as is generally known, the depth exceeds 30 feet for more than 200 feet in width.

We are informed that the works required to confine the flow of water from the main river, above the common head of the passes, into South Pass, so as to secure a like deep channel entrance to South Pass over the river middle-ground shoal about its head, are being energetically prosecuted with every prospect of early success. Already, notwithstanding the low stage of the river, the one-dipper dredge boat at work there to expedite the cutting out of a deep channel entrance, has succeeded, as we are assured, in obtaining a depth of inlet of from 20 to 22 feet across this choal, which the tidal current suffices to maintain and widen. Soon, we are told, two more powerful dredges will be put to work there, and with three boats working together, an entrance channel across this hard sand middle-ground shoal, of sufficient width and depth for the largest class of ocean steamers, even at the present low river stage, may be expected at an early date. With the river at the height it was three months ago, we would have, even now, a clear and unobstructed channel of more than 22 feet in depth, from New Orleans to the sea, through South Pass.

FRICTION OF PLAIN SLIDE VALVES.

By JOHN W. HILL, M. E.

[From the *Engineering and Mining Journal*, February 5, 1877.]

Several months ago the writer, in the routine of duty as a contributor to a Western mechanical journal, furnished for publication an article under the above head. The paper had for its purpose an exposition of the true relative power expended in moving the ordinary slide valve of steam engines, with such hints upon the construction as would aid designers in reducing the loss of power by friction of the valve to a minimum. Since its original publication, the article has been reproduced in other papers, and variously commented upon. The vigor and pertinacity with which the writer's conclusions upon this topic have been disputed by certain parties in interest, induces the present paper, which, it is hoped, will place the matter in such a clear light as to remove all doubt upon the accuracy of the results deduced.

As an index to the present investigation, it should be understood that for several years past a class of semi-mechanics have been peddling about the country various kinds of balanced slide valves, some of which are ingenious in construction, whilst the majority fail to command even casual attention, and all are worthless when placed squarely upon their merits, as their purpose is to substitute for an insignificant evil a greater though less obvious one. Owners of steam engines have been surfeited with circulars and testimonials commending the various traps; and after the benefits of the circular system have been completely exhausted, the inventor himself usually commences his pilgrimage. In due time he opens an assault upon some luckless owner of a steam engine, by explaining in technical terms the many virtues of his improved valve, and the utter lack of these desirable qualities in all valves hitherto in use. There are few owners of engines who can successfully resist the seductive charms of the "new valve," and in due time the owner consents to have his otherwise good engine "improved" by the industrious semi-mechanical missionary.

The projectors of these improved valves are rarely modest men. Those, however, having a regard for the remote future, limit their

claims of saving in cost of the power to be effected by the use of *their* valves at from 15 to 25 per centum, whilst others with a more elastic conscience usually estimate the benefits to be derived from "*their*" valves at from 25 to 50 per centum. Obviously, the only saving that a relieved valve can effect, as compared with an unrelieved valve, is the power expended in moving the latter. Conversely, there is not a single relieved valve in use, so far as the writer is aware, that has not, in a very short time after introduction, become so leaky as to render it a nuisance in the enormous quantity of steam passed into the exhaust, without performing its office in the cylinder, the steam thus wasted entirely obliterating any beneficial effect that might be obtained from a reduced load on the valve. Railway master mechanics who have investigated the relative merits of relieved and unrelieved valves, generally agree that the wear of links and joints of valve gears is least with relieved valves. Upon the other hand, they quite as unanimously agree that the relieved valves soon become excessively wasteful of steam, and that no increased economy of performance is perceptible in their use. Upon the whole, the experience of railway mechanics appears to decide the relieved valve as inferior to the plain slide valve (vide Rep. M. M. Convention, 1874).

The purpose of this article, however, is not in disparagement of relieved valves, but rather to show that such valves are the result of an imperfect knowledge of the friction of the unrelieved valve in its simplest form. That this imperfect conception of the true relative power expended in moving the valve is not confined to obscure persons, is evidenced by an article in the *Scientific American* under date of September 30th, 1876, in which the editor says: "If we consider the valve of an ordinary 16-inch cylinder engine to measure 8·5 by 14 inches, and allow a pressure of 130 pounds per inch in the steam chest, there would be, supposing the valve to bed perfectly on its seat, a pressure of $8{\cdot}5 \times 14 \times 130 = 15{,}470$ pounds forcing the valve to its seat; and the whole pressure upon the piston being 26,442 pounds, the friction of the valve would entail a loss of $\frac{15{,}470}{26{,}442} = 58$ per centum of the power of the engine."

The quotation contains two erroneous assumptions: first, that the friction is a measure of the area of the valve into the pressure per square inch independent of well-known coefficients of frictional con-

tact; and second, that the travel of valve is equal to the stroke of piston. Taking the data of the editor and allowing 20 per centum as the coefficient of friction for cast iron on cast iron, and the travel of valve as ·2 of the stroke of piston, then the power absorbed by friction of the valve becomes $58 \times \cdot 20 \times \cdot 2 = 2 \cdot 32$ per centum of the power of the engine, instead of 58, as estimated by the editor.

The general treatment of the "power absorbed by friction of the ordinary slide valve," in the accepted text-books on the steam engine, is vague and in nowise calculated to convey to the mind of the student the exact *status* of the problem. Rankine observes that "the slide valve is pressed to its seat, and the joint between it and its seat kept steam-tight by the excess of the pressure of the steam in the valve chest, behind the valve, which comes from the boiler, above the pressure of steam in the interior of the valve, which communicates with the condenser or atmosphere. The amount of pressure of the valve against its seat due to the pressure from behind is the product of the intensity of that pressure into the area of the face of the valve." Again, he says that "in the cases of large valves the load of resistance is unnecessarily great."

It is an undeniable fact that as the area of valve increases, the actual power required to move it increases; and in the case of large engines provided with slide valves, the force required to move them may be so great as to make it desirable that they be relieved, so as to allow ready manipulation in reversing and shifting the link, or other variable expansion gear; but if this convenience of handling, and reduced expenditure of power in moving the valve is obtained with a sacrifice of economy in the performance of the engine, the question presents itself whether it is not preferable to use the slide valve in its simpler form, with the corresponding economical performance, than to substitute relieved valves wherein the loss of steam between the valve face and its seat, into the exhaust, more than compensates for the increased facility of manipulation.

The writer is unaware of any experiments being reported, except by parties in interest, upon the relative economy of the different systems of slide valve; but from such data as he has been able to collect, he is of the opinion that the highest grade of economy is to be obtained from engines with the plain valve.

Evidently the expenditure of power in moving the ordinary slide valve is the moment of friction into the travel, and the moment of

friction is a function of the surface in contact and the unbalanced load on the steam side of valve (the total load being the area of the back of valve, parallel to the plane of motion, into the pressure in the chest). From this it appears incidentally that the smaller the valve for a given effect, the less the power absorbed in moving it. An erroneous idea prevails among engine builders that the friction of the valve is entirely independent of its size, and only dependent upon the area of steam passages which it covers. The fallacy of this conception will be evident in the following demonstration:

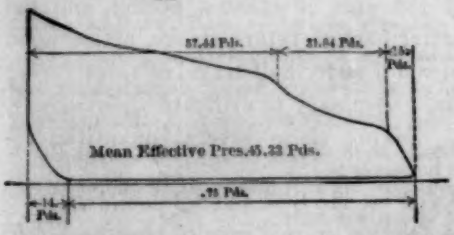
Let A represent the area of valve parallel to face impinged upon by the steam in the chest, and P the intensity of pressure in the chest. Assuming A as a constant for all positions of valve, then the total load upon the valve perpendicular to the plane of motion becomes $A \times P$; and were it not that a portion of this quantity is neutralized in its effect by a force also acting in a plane perpendicular to the motion of valve, and diametrically opposite to the force $A\,P$, then this latter, modified by a proper coefficient, would represent the moment of friction at all points in the travel.

Let A' represent the effective area of under side of valve referred to, complete stroke of piston, and P' the corresponding mean pressure, then $A' \times P'$ is the neutralizing force; hence the moment of friction, F, is a function of $AP - A'P'$. Let B represent the travel of valve in feet; then the expenditure of power in overcoming the resistance of friction in the valve is expressed by the equation:

$$H = \frac{F \times B \times 2r}{33{,}000} \quad . \quad . \quad . \quad . \quad (1)$$

Let H' represent the indicated horse-power of engine, then the per centum of power, K, thus expended, becomes:

$$K = \frac{H}{H'}\,100 \quad . \quad . \quad . \quad . \quad . \quad (2)$$



To exemplify the foregoing principles the writer assumes an engine of 16-inch cylinder, 400 ft. speed of piston; slide valve 8¾ by 14 inches; travel, 5 inches; steam ports, 15 sq. inches area; exhaust port, 24 sq. inches area; pressure in the chest, 85 pounds; steam cut-off, at ⅞ piston stroke. The diagram is from

an engine of these dimensions, and has been carefully estimated for this demonstration.

The area of valve parallel to the plane of motion is $8{\cdot}75 \times 14 = 122{\cdot}5$ square inches, pressure in the chest, 85 pounds, and the total load, $122{\cdot}5 \times 85 = 10412$ pounds; the counter-pressure acting upon the opposite side of the valve is made up of the mean pressure from admission to cut-off, acting upon an area equal to the area of steam port, for half travel of the valve in opening and closing port, hence:

$$\frac{15 \times 57{\cdot}44 \times 1{\cdot}25}{5} = 215{\cdot}4 \text{ pounds.}$$

The mean pressure from cut-off to release, acting upon an area equal to the area of steam port, for whole travel of valve during expansion:

$$\frac{15 \times 31{\cdot}84 \times 1{\cdot}25}{5} = 119{\cdot}4 \text{ pounds.}$$

The mean pressure from release to end of stroke, acting upon an area equal to the area of steam port, for half travel of valve during release:

$$\frac{15 \times 15 \times {\cdot}625}{5} = 28{\cdot}125 \text{ pounds.}$$

The mean counter-pressure from commencement of return stroke to exhaust closure acting upon an area equal to the area of exhaust pocket in valve, area of exhaust, pocket $12 \times 3{\cdot}75 = 45$ sq. in., hence:

$$45 \times {\cdot}75 \times {\cdot}9 = 30{\cdot}375 \text{ pounds.}$$

The mean cushion pressure from exhaust closure to opening of steam port at commencement of new stroke, acting upon, and equal to, the area of steam port for whole travel during compression:

$$\frac{15 \times 14 \times 1{\cdot}25}{5} = 52{\cdot}5 \text{ pounds.}$$

In addition to this is the value of the mean pressure from release to end of stroke, acting upon the area of exhaust pocket, and the counter-pressure during the latter part of return stroke, acting upon an area equal to the area of steam port for half travel of valve during exhaust closure, lacking the data necessary to estimate their values, these elements are omitted. Taking these several quantities together, the neutralizing force becomes:

445·8 pounds, then $10{,}412 - 445{\cdot}8 = 9966{\cdot}2$ pounds.

Assuming the coefficient of friction in this case to have been ·15, then $9966{\cdot}2 \times {\cdot}15 = 1494{\cdot}93$ the moment of friction, the double

travel of valve ·83 ft., and the revolutions per minute 100, then:

$$\frac{1494{\cdot}93 \times {\cdot}83 \times 100}{33{,}000} = 3{\cdot}76 \text{ H. P.}$$

The mean effective pressure by the diagram is 45·33 pounds; area of piston, 201; piston speed, 400; and the indicated power of engine becomes:

$$\frac{201 \times 45{\cdot}33 \times 400}{33{,}000} = 110{\cdot}5 \text{ H. P.}$$

and the per centum of power expended in moving the valve:

$$\frac{3{\cdot}76}{110{\cdot}5} \times 100 = 3{\cdot}4.$$

The opinion entertained by certain engineers that the slide valve floats on a thin film of steam between it and its seat, is not only untenable, but undesirable, for if the fit of the valve to its seat is such as to allow a circulation of steam of maximum pressure sufficient to balance the load (in part) upon the opposite side of the valve, it is likewise sufficient to permit the passage of steam between these surfaces into the exhaust. Again, considering the close relation that must necessarily subsist between the valve and the seat in order to *prevent* leakage into the exhaust, it is probable that the liquefaction of steam, due to the attraction of the metal surfaces, is sufficient to prevent the entrance of steam under the valve.

Safety of Railroad Traffic as ensured by the Block System of Signals.—A severe accident has occurred in England, on the line of the Great Northern Railway, near Arlesley, which shows that a perfect system of signalling is incapable of prevention of accidents, unless it is supplemented by infallible means of stopping a train within the signal limits. In this case with the signals at danger while a goods-train was crossing the line, upon which it broke down, the express-train of 15 carriages run through the signals at over 800 yards distance, and came in collision with the goods-train at a speed only checked from 60 to 20 miles per hour.

A continuous brake would have averted this catastrophe, but the perfection of such a brake is an indispensable condition for complete safety. It would seem that there is no possible perfect immunity from railway accidents.

GAS SUPPLY FROM WORKS WITHOUT A GASHOLDER.

By M. Servier.

Paper read at the last Annual Meeting of the *Société Technique de l' Industrie du Gaz en France.*

[From *The Journal of Gas Lighting*, London, Jan. 9th, 1877.]

The object of the communication I am about to make to the Society is to demonstrate the possibility of gas-works performing their functions without the aid of a gasholder. It is evident that here the question is not one of a normal supply, and though I made the experiment with it, I beg you to believe that it was not for my personal amusement. First of all, then, I will state the causes which led me to make this experiment, which was attended with perfectly successful results.

The contract for lighting the town of Metz has been but lately renewed, and the considerable reduction in price which has resulted therefrom—a reduction from 45 to 27 centimes per cubic mètre (about 10s. to 6s. per 1000 feet), upon which the town authorities impose a further tax of 5 centimes, making the net price 22 centimes—has proportionately developed the consumption of gas. It has also compelled us to seek for more economical modes of manufacture.

The old gas-works at Metz, constructed at a time when the railway was not in existence, were erected on the road from Metz to Saarbruck, where the coal mines are situated; but the railway terminus was built at the other end of the town, about three miles from the gas-works. The first piece of economy to be practiced in the development of the manufacture was, therefore, to move nearer to the railway terminus, and this we did by erecting a second gas station close to the line. This station was destined subsequently to replace the original works. These new works were furnished with larger retort-ovens, and so arranged as to manufacture gas more economically.

I was pledged to light the railway offices, etc., in the month of October, 1875, but, in consequence of delays, I was unable to complete the gasholder in time to be of service. Then came the frost, and, briefly, I found that the gasholder could not be brought into use till the Spring. However, I wished to fulfil my engagements, and add to the receipts the amount which the lighting of the railway offices would have brought us.

It was under these circumstances that I decided on starting the works without a gasholder, and I am about to point out to you the precautions to be taken in a similar case, and to explain how, although I got very well out of the difficulty, I might have done still better than I did, had I thought sooner of another solution, which I have just applied with a different object.

I ought at once to say that the existence of the old works, with the gasholder, facilitated the service I wished to effect, by reason of the connection existing between the two stations through the network of mains; but it will be seen that this condition is not necessary.

The day supply, as well as that which is furnished after midnight, is very regular in the majority of towns; that is to say, the hourly consumption is pretty nearly equal. This consumption being known, it is sufficient to charge the retorts with the quantity of coal absolutely necessary for the production of the amount of gas desired, sending the gas direct into the town. This is what was done during the day, and after midnight. With regard to the evening, the retorts were fully charged, and the two works being connected by the mains I was able by means of the governor, so to regulate the supply from the works provided with a gasholder as to leave the works unprovided with one to send out all the gas they produced. In this way the pressure on the retorts and other apparatus did not exceed the proper limits, which would not have been the case if the works without the holder had produced more gas than they were able to send out.

But this regulation of the charges during the day and night, and of the pressures during the evening, is not the only precaution to be taken in a service of this nature. You know, in fact, that the coal does not produce, during the different periods of its distillation, a uniform quantity of gas, or gas having a uniform illuminating power. The first portions of the gas produced, like those which are given off last, have a much more feeble illuminating power than the gas produced in the middle of the distillation. To remedy this serious inconvenience, the retort charges were fractionated as much as possible—that is to say, every hour a fourth of the retorts were charged in order to obtain a gas of an average illuminating power. We even noticed that, notwithstanding this precaution, it was necessary to add a small quantity of Boghead or cannel to each charge, to improve the gas produced at the commencement of the distillation.

It is equally necessary, during the lighting hours, to refrain from putting into use purifiers that have just been renewed, and contain air, which acts injuriously on the illuminating power of the gas, unless the precaution be taken to expel the air by means of valves in the covers.

The same supply could be afforded by a single work which, from any circumstance whatsoever, had been deprived of its gasholder; but it would be necessary to take a fresh precaution, which would be before sending the gas into the town, to cause it to pass through a small bell-shaped vessel suspended in water, and weighted to the maximum pressure, which it was desired that the apparatus on the works should bear. This vessel would be furnished with an outlet-pipe, which would allow the gas to escape whenever the proper pressure should be exceeded. The gas so escaping might go to waste, or, better still, be conveyed into the retort-oven, and there utilized for keeping up the heat. I should add, that in one case as in the other it is indispensable to entrust the service to intelligent and conscientious foremen.

I have already said that I could have done still better if I had thought in time. This is what I am now actually doing, although the gasholder is in use, but with a different object, which I am about to indicate to you. I have remarked that the new works were capable of manufacturing gas at a lower rate than the old, consequent upon the economy effected in the transport of the coal and the employment of improved apparatus. But beyond this the old works possess extensive gasholders and large outlet-pipes. These I was desirous of utilizing, while making the gas exclusively in the new works, at least during a great portion of the year. For this purpose I connected one of the outlet-pipes at the old works, in front of the outlet-valve, with the inlet to the exhauster. In this way the old works draw off by means of the network of mains, the gas made during the day by the new, store it in the holders, and send it out in the evening through the large outlet-pipes. I can thus draw off 150 cubic mètres (about 5000 cubic feet) per hour without any inconvenience. I do not increase the leakage, as the suction of the exhauster is so regulated that the pressure on the mains is unaltered. There is, however, a slight oscillation produced by the exhauster, which is on Beale's system; but that is of no importance for day consumption, and moreover could be entirely suppressed by using one of Schiéle's or Körting's exhausters, the action of which is much more

regular, or by interposing a governor between the main and the exhauster. But I repeat, the oscillation is so slight that it is not even necessary to make this addition.

You see, then, that I could have saved myself the trouble of regulating the retort-charges with so much care on the works unprovided with a gasholder, by drawing off, as I now do, the gas produced there, and storing it in the holders on the second works. But we do not always think of everything, and thus an opportunity was afforded me of making an experiment which perhaps may be of some use in exceptional cases.

Roll Turning.[1]—The three memoirs on roll turning, to which prizes were awarded a few years since by the Verein zur Beförderung des Gewerbfleisses in Preussen (Prussian Society for the Promotion of Industry), have just been issued by permission of the Society as a separate volume of 135 large quarto pages, with 33 lithographed plates, and 108 cuts in the text. The volume is obtainable in this country of Messrs. Williams & Norgate, of Henrietta Street, Covent Garden, and as the price—24*s.*—is not high, it will, doubtless, be accorded a place in the library of all iron manufacturers who desire to keep themselves informed with regard to what is being done by their rivals in Germany. It will be recollected that some ten years since the Society offered prizes of 500 thalers and 250 thalers respectively for the best and second best memoirs upon the subject in question, the offer of the prizes being the result of a discussion which took place at one of the meetings of the preceding year. The various points upon which information was sought were carefully detailed in the conditions of competition, and the several competitors were required to send in their memoirs, distinguished by motto only, in the usual way, so that the selection for the award was necessarily made upon merit alone. The award having been made it was found that the 500 thaler prizes had been gained by Mr. R. Daelen, superintendent engineer at Hörde, now owner of a factory at Heerd, near Düsseldorf, and by Mr. A. Hollenberg, engineer, at Sterkrade, now superintendent engineer at Essen; whilst the 250 thaler prize was gained by Mr. Diekmann, engineer, at Eschweiler-Pümpchen, near Aix-la-Chapelle. The memoir by Mr. Daelen is concise, and to the point, the various arrangement of rolls, two and three high,

[1] From the *Mining Journal*, London, Jan. 6th, 1877.

being described, and the method of ensuring their accurate working explained; ample details are also given as to roughing and finishing rolls for ordinary merchant bars, and to the rolls for the production of special sections. The details given by Mr. Hollenberg are still more minute, and will be found to be of equal practical value, whilst Mr. Diekmann's memoir is also an admirable one. Whether the manufacture be principally engaged in rolling T, double T, U, angle iron, hoops, rails, bars, tramplates, or special sections, he will find so much information of the precise character he requires that even should he disagree with some of the conclusions arrived at, he will at least be prevented from falling into error by neglecting the considera tion of details which demand attention.

ORIGIN OF PETROLEUM.

Mr. H. Byasson has been led by the following experiment to give a scientific explanation of the formation of petroleum: If a mixture of vapor of water, carbonic acid, and sulphuretted hydrogen be made to act upon iron, heated to a white heat in an iron tube, a certain quantity of liquid carburets will be formed. This mixture of carburets is comparable to petroleum.

The formation of petroleum can thus be naturally explained by the action of chemical forces.

The water of the sea, penetrating into the cavities of the terrestrial crust, carries with it numerous materials, and especially marine limestones. If the subterranean cavity permits these new products to penetrate to a depth where the temperature is sufficiently high, in contact with metallic substances, such as iron or its sulphurets, we have a formation of carburets. These bodies will form part of the gases whose expansive force causes earthquakes, volcanic eruptions, etc.

Petroleum is always found in the neighborhood of volcanic regions or along mountain chains.

In general it will be modified in its properties by causes acting after its formation, such as partial distillation, etc. Petroleum deposits will always be accompanied by salt water or rock salt. Often, and especially where the deposit is among hard and compact rocks, it will be accompanied by gas, such as hydrogen, sulphuretted hydrogen, carbonic acid, etc.—Translated from the *Revue Industrielle* for the *American Manufacturer.*

VENTILATING APPARATUS.

[From the Secretary's Report to the Meeting of the Franklin Institute, Jan. 17, 1877.]

There were exhibited at this meeting several modifications in the caps of chimney or ventilating shafts, and in deflectors for currents from hot-air registers, which had been designed and put into practical use by Mr. Wm. Welsh. These appliances were described in full, as follows:

First, a chimney or ventilating shaft was protected from the weather and any wind, which might at any time exist about the top and was made to induce an outflowing, upward current, by a cap of peculiar construction, as shown on Fig. 1. This cap could be round, but might preferably be square; it had a surface, inclined at about 45°, which came to a sharp point at the flue, so that any horizontal current of air which exists at the time should be deflected upwards, and thus induce the ascending smoke or foul air in the flue to pass out with it. The top was protected by a flat plate, which was made to extend well over and beyond the inclined surface, so that any downward current in the external air would be transformed into a horizontal one in some direction, before reaching this inclined surface. In so far as this description goes, the cap is that well known as Emerson's Ventilator, which was patented about 1847,[1] but Mr. Welsh has found great advantage in the addition of four vertical radial wings or plates, which answer the purpose of preventing whirls of descending external currents from choking the efflux from the flue. In fact these whirls, which frequently exist wherever the chimney-top is surmounted in elevation by houses or roofs, now are made somewhat effective in inducing a draft in the chimney or ventilating flue, while they also, by *catching* in the funnel-shaped mouth the full force of the horizontal, or nearly horizontal, currents, ensure the best effect from these currents on the affluent smoke or air.

Fig. 1.

[1] This form of ventilator was really originated by Cisalpen, ninety-nine years ago. See Memoir in Phisiq. de M. Rozier, Tome ix, 1777.

Second, a ventilating shaft, in which the inducement for ascent of the foul air current is given from heat proceeding from an internal smoke flue (an arrangement at once common, and generally satisfactory), will be found more efficient if the cap be constructed as shown on Fig. 2. The smoke flue (of cast iron preferably) is made to stop short, below the outlet of the stack, so that a commingled volume of air and smoke escapes at the top. This arrangement was effectual in taking advantage of the hot gases current, as a *jet*, to quicken the discharge of the air flue; at the same time, the increase of temperature of the currents was made more certain than by mere contact with the smoke-stack, and the construction of the stack was greatly simplified. This disposition was practically in use in the new pavilion wards at Wills' Hospital, and at the Pennsylvania Institution for the Deaf and Dumb, where the system of ventilation was rendered very effectual by its means.

Fig. 2.

Third. For larger shafts and ventilating louvers, Mr. Welsh proposed the arrangement shown on Fig. 3. The lower part of this louvered opening, Mr. Welsh proposed to construct similarly to the caps Fig. 1 & 2, with radial wings in the four corners of the louver in the same way, but above this to employ a system of blinds or slats of peculiar form, so that a current of wind blown against them would be *deflected*, inducing an outward flow from the narrow slits left between the upper edge of one deflector strip and the under side of the next above it. This supposed effect will be readily comprehended by reference to the figure and its arrow.

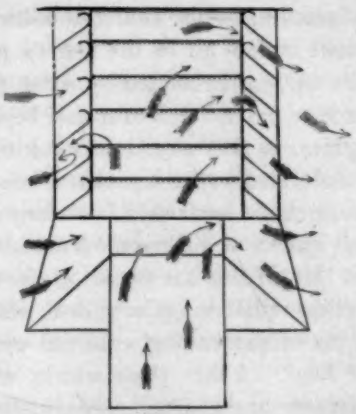


Fig. 3.

Fourth. For the louver openings of shafts for *supply* of air to a system of ventilation, Mr. Welsh proposes an arrangement of blinds or slats, and internal construction as shown on Fig. 4: by so forming

the slats as to present a wide open mouth to the current of wind, constraining it to deviate from a horizontal direction and thus directing its discharge downwards into the shaft. By this means the force of the wind itself will be rendered available on one side certainly, and possibly on two sides (if the direction of the wind is diagonal to the position of the square louver). Within the louver and for a short way down the shaft, some division plates separate it into four flues. These

Fig. 4.

division plates preclude any direct flow of the air across the louver—to escape at the opposite side and ensure a determinate downward current in the flues on the windward side of the louver or shaft—while this downward current *induces* in part a similar flow in the flues on the leeward side, the blinds of which receive their air from the whirl which the wind will make over the louver as it does over any obstacle whatever.

In the ventilation of buildings by self-acting currents it is well known that in high winds the heating air refuses to enter at the registers of the lower exposed rooms. The pressure of wind against the windows, the leakage, and possibly the passage of some air through the wall itself, will have produced such a plenum in these rooms as to oppose the entry of air at the usual flues. Sometimes the air of a room thus situated will actually flow back to the heater through the flues, and the system of ventilation will be reversed, the room being supplied with *cold* air by leakage or otherwise. This construction of ventilating shaft now provides a pressure upon the cold air supply for the furnaces quite equal in value, and possibly exceeding that which the wind will have established in the exposed room, and the entry of a current of hot air is thus ensured for that room, regardless of the force of the external wind.

Fifth. For the distribution of heated air in a room, Mr. Welsh proposed to have constructed a *deflector*, as shown on Fig. 5. This *deflector* would, by a judicious shape of blades, direct the current of heated air upon the floor of the room, in place of allowing it to escape horizontally at first emergence and thence ascend, like a reversed discharge of water,

Fig. 5.

in a curved line to the ceiling. When the current of heated air once was established on the surface of the floor, it would not, according to

well known observations (first made by Venturi, who found that a jet of air would never leave a surface upon which it is blown), arise from the floor until it is diverted from it, by some object of resistance. This apparatus has proved very successful in practice, and Mr. Welsh has made some arrangements for its introduction into general use in promoting a healthy equality of temperature of air in occupied rooms. Another arrangement of deflector is shown on Fig. 6, suited for giving a horizontal surface direction to currents from floor registers. The figure and arrows show the effect of the deflecting plate, which is so shaped as to offer the least resistance to the stream of air compatible with the change of direction.

Fig. 6.

Sixth. For the control and distribution of inflowing currents, either under great variations of pressure, or when a small flue is employed in which the air attains a high velocity, while it is desirable that the entering current shall be nearly imperceptible, the arrangement on Fig. 7 is proposed. By this disposition of ⊢⊣ bars, the direction of the current is so baffled, and so many eddies produced, that the vehemence of any stream of air is quite spent when the front of the *distributor* is reached by it.

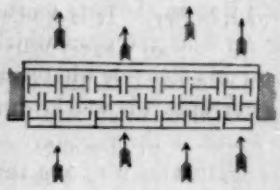


Fig. 7.

Except the fifth of the list, the right for which Mr. Welsh has donated to some charitable purposes, none of these several arrangements have been or will be patented. Whatever novelty or value the others may possess, Mr. Welsh has taken this means of making them public, for the purpose of rendering them free from patent fees, for all persons who may at any future time have occasion to use them.

Heating Railway Carriages.—All classes of carriages on the Alsace-Lorraine lines are now warmed, the supply of heat being the boiler of the locomotive. Metallic standpipes are placed in each carriage beneath the seats, connecting with a main running the length of the carriage. Each of these is connected with the next by india-rubber tubing, the whole forming a continuous supply. Each compartment has its own supply, which the passengers can regulate for themselves, by moving a lever placed on a sector bearing the words *cold, warm, hot.—Iron.*

ON THE LANCASHIRE BOILER,

ITS CONSTRUCTION, EQUIPMENT, AND SETTING.

By Mr. Lavington E. Fletcher, of Manchester.

[From the *Proceedings of the Inst. Mech. Engineers*, London, May, 1876.]

The Lancashire type of Boiler differs only from the Cornish in one point, namely, that the Lancashire boiler has two furnace-tubes whereas the Cornish has but one. In both types of boiler the shell is cylindrical, the ends are flat, and the furnace tubes are carried through from front to back below the ordinary water line, while the boilers are laid horizontally and fired internally. Internal firing is essential either to a Lancashire or to a Cornish boiler. It is a mistake to speak of an "externally-fired Lancashire" or an "externally-fired Cornish" boiler, though this is frequently done. If the fires are taken out of the furnace-tubes of a Lancashire boiler and put underneath, it is a Lancashire boiler no longer, but becomes an externally-fired double-flued boiler; and if a Cornish boiler be treated in the same way, it becomes an externally-fired single-flued boiler. These boilers owe their names to the counties in which they were first brought into general use. The single-furnace boiler was introduced early in the present century by Trevithick in Cornwall, and is therefore called Cornish. The double-furnace boiler was introduced in 1844 by Fairbairn and Hetherington in Manchester, and is therefore called Lancashire.

In laying down Lancashire boilers, the fact has been too frequently lost sight of that directly a fire is lighted within them they begin to move, the flat ends to breathe outwards, the furnace tubes as well as the shell to hog upwards, and the whole structure to elongate. If sufficient allowance is not made for these movements, straining and sometimes rupture occurs, while the tendency to this is frequently aggravated by putting in an extra thickness of metal with a view of adding strength, the additional thickness increasing the unequal expansion of the parts. For some years the writer has had opportunities of observing a large number of boilers of the Lancashire as well

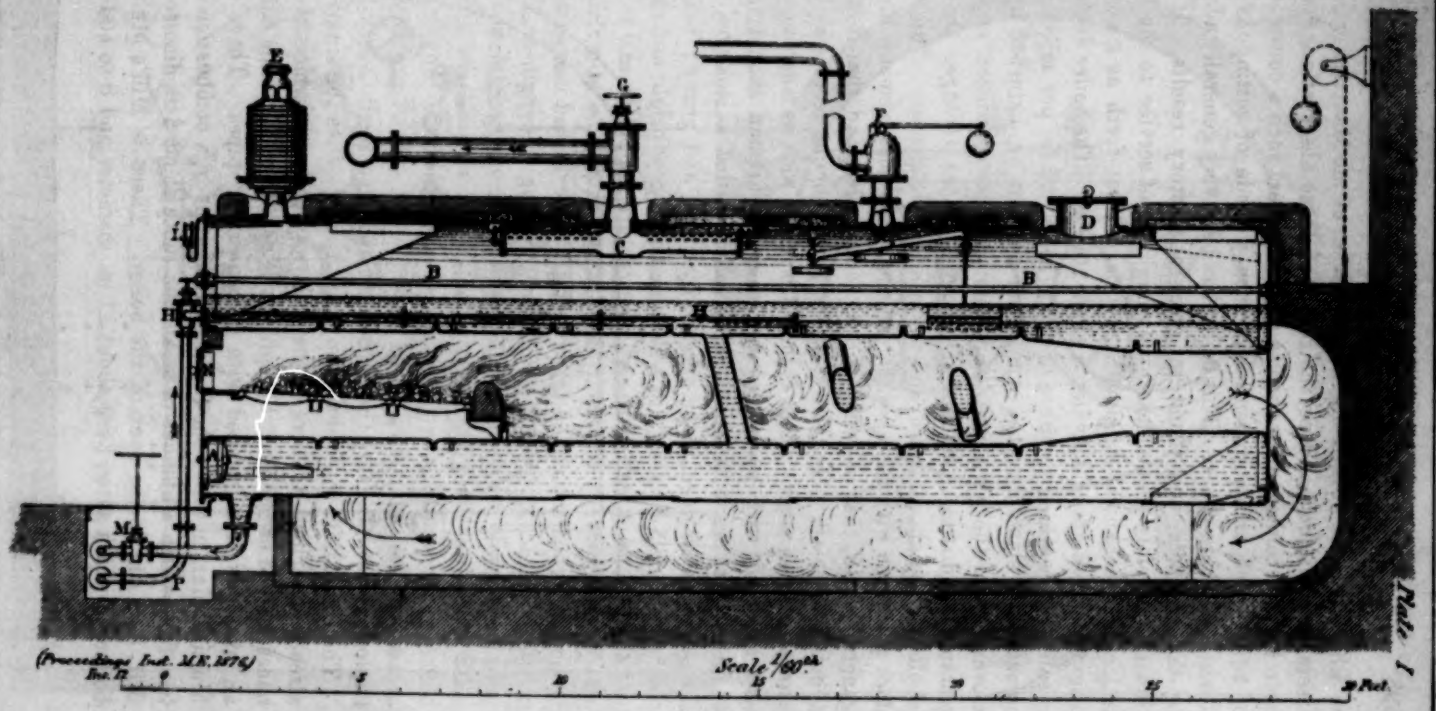
as other types, in work under the inspection of the Manchester Steam Users' Association; and as the result of these observations he has been led to recommend for the use of its members such a construction of boiler, such an equipment, and such a mode of setting, as that described in this paper. This boiler has been very generally adopted by the members, and found to give satisfactory results. It was thought therefore that a description might be of service to the Institution of Mechanical Engineers. It is not set forth as a work of origination but one of selection and adaptation. The boiler described is safe for a working pressure of from 75 to 100 lb. per sq. in. Its structure is elastic, so that it may not be rent or disturbed by the movements of the parts, resulting from alternate expansion and contraction; and it is so set and the fittings are so arranged that the whole may be above board and accessible to inspection The writer does not agree with the view, so obstructive to improvement, but too generally held, that anything will do for a boiler, and that it is only a boiler after all. He thinks that a boiler should receive as much attention as an engine; that it should be made with as much accuracy and attended with as much care; that the fireman should not be condemned to work in a dark dirty cellar, called a stoke-hole, and the boiler be assumed to be necessarily black and grimy; but that the boiler should be placed in a suitable house kept bright and cheery, and the fittings as well as the whole structure kept clean and in first-rate working order; also that the fireman should be stimulated to become as proficient in the art of using his shovel and managing the fire as a fitter in using his file and erecting an engine. If this practice, happily adopted by some, were to become general, and first-class boilers were laid down instead of low-priced ones, the scientific boiler-maker would have fairer scope, the steam user would derive economy, and the public would be benefited by the prevention of explosions as well as by the abatement of the smoke nuisance.

The Lancashire boiler has many variations, besides the simple form already described. There is the Galloway boiler, in which the furnaces instead of running through from one end to the other unite in an oval flue strengthened with conical water pipes. There is the Multitubular, in which the furnace-tubes unite in a combustion chamber, from which a number of small flue tubes about 3 in. diameter and 6 ft. long run to the back of the boiler. There is Hill's Multiflued boiler, in which seven flues about 11 in. diameter and 8 to 10 ft. long

LANCASHIRE BOILER.

Plate 1

Fig 1. *Longitudinal Section.*



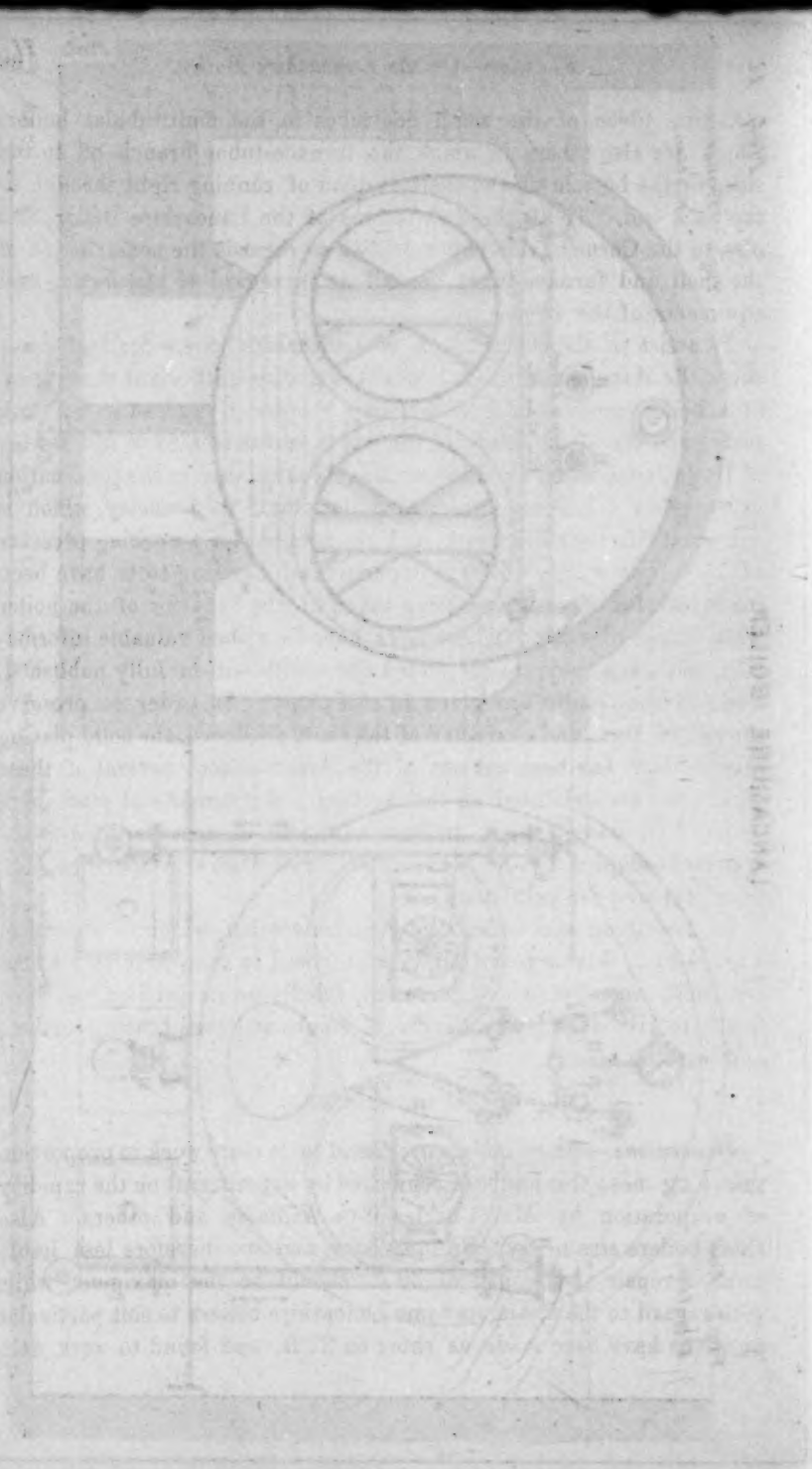
(Proceedings Inst. M.E. 1874)

Plate 1

PARTRIDGE, PHOTO-LITH.

JOURNAL OF THE FRANKLIN INSTITUTE.

VOL. CIII.



take the place of the small flue tubes in the multitubular boiler. There are also others in which the furnace-tubes branch off to the sides or the bottom of the shell, instead of running right through to the back end. To all these variations of the Lancashire Boiler, and also to the Cornish, this paper applies as regards the construction of the shell and furnace-tubes, as well as in regard to the setting and equipment of the whole.

To assist in the construction of Lancashire boilers for high pressures, the Manchester Steam Users' Association authorized the making of a boiler expressly for undergoing a series of hydraulic bursting tests; and the manufacture of the boiler was entrusted to Mr. Beeley of Hyde Junction, who rendered valuable assistance in the prosecution of the trials. This experimental boiler was 7 ft. diameter, which is the usual size for mill service, and was adapted for a working pressure of 75 lb. per sq. in. Eleven experimental bursting tests have been made, careful observations being taken of the behavior of the boiler while under pressure. These tests have furnished valuable information, and when they are completed the results will be fully published. Some of the results are given in this paper. In order to preserve the precise form and character of the rents produced, the solid plating around them has been cut out of the boiler intact; several of these specimens are exhibited at the meeting. An actual end plate of a boiler 7 ft. diameter, got up and equipped in accordance with the standard adopted by the Manchester Steam Users' Association, has been prepared for exhibition.

In describing the boiler under consideration, which is shown in Figs. 1 to 3, Plates I and II, it is proposed to treat first on its construction, secondly on its equipment, thirdly on its setting, and then finally to give a few particulars as to weight and cost, heating surface, and working results.

Construction.

Dimensions.—Short boilers are found to do more work in proportion than long ones; this has been confirmed by experiments on the rapidity of evaporation by Mr. Charles Wye Williams and others. Also short boilers strain less than long ones, and are therefore less liable to need repair. A length of 30 ft. should be the maximum, while with regard to the minimum some Lancashire boilers to suit particular positions have been made as short as 21 ft. and found to work well,

though the fittings become rather crowded. The length recommended and now generally adopted is 27 ft.

The diameter of the boiler is governed by the size of the furnaces, which should not be less than 2 ft. 9 in. to admit of a suitable thickness of fire and afford convenience in stoking. Thick fires are more economical than thin ones. The space between the two furnace-tubes should not be less than 5 in., and that between the furnace-tubes and the side of the shell 4 in., in order to afford convenient space for cleaning and for the free circulation of the water, as well as to give sufficient width of end plate for enabling it to yield to the expansion and contraction of the furnace-tubes. With this width of water space it will be found that furnace-tubes having a diameter of 2 ft. 9 in. require a shell of 7 ft., which will afford a headway of about 2 ft. 9 in. from the crown of the furnaces to the crown of the shell. A furnace 3 ft. diameter gives room for a thicker fire than one 2 ft. 9 in., but it requires a shell 7 ft. 6 in. diameter. For high pressures, the smaller diameter of 7 ft. is generally preferred, and has come to be adopted as a standard size for mill boilers throughout Lancashire, though one of 7 ft. 6 in. makes a good boiler and gives a greater Ind. H. P. per lineal foot of frontage than one of 7 ft. The diameters both of the shell and of the furnace-tubes are measured internally, that of the shell being taken at the inner ring of plating.

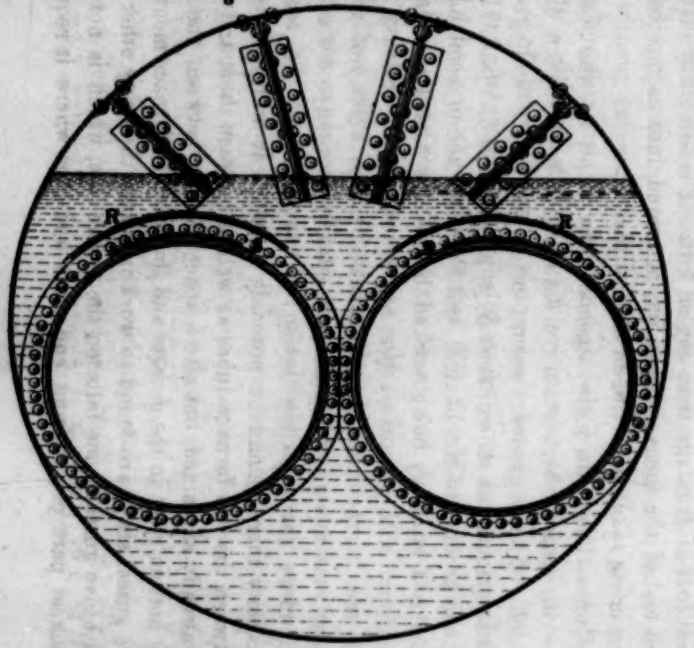
Ends.—The ends, more especially the front, are the seat of the grooving action which occurs in Lancashire boilers when disproportioned. These grooves occur inside the boiler and around the furnace mouth, as shown at *R S* in Figs. 4 and 5, Plate III. They are the product of mechanical and chemical action combined. The plate is fretted by being worked backwards and forwards by the movement of the furnace-tubes consequent on the action of the fire, and when in that condition is attacked by the acidity of the water. To prevent this grooving, the ends should be rendered elastic so as to endure the buckling action without fatigue. To secure this elasticity there should be not only a sufficient width of end plate between the two furnace-tubes as well as between them and the shell, as already explained, but also a space of 9 in. between the centre of the bottom rivet in the gussets and those at the furnace mouth. Also five gusset stays are found to work in better than any other number. With five gussets, one falls on the centre line, which is not only the weakest part of the front end plate and thus where it requires the

LANCASHIRE BOILER.

Grooved End Plate.

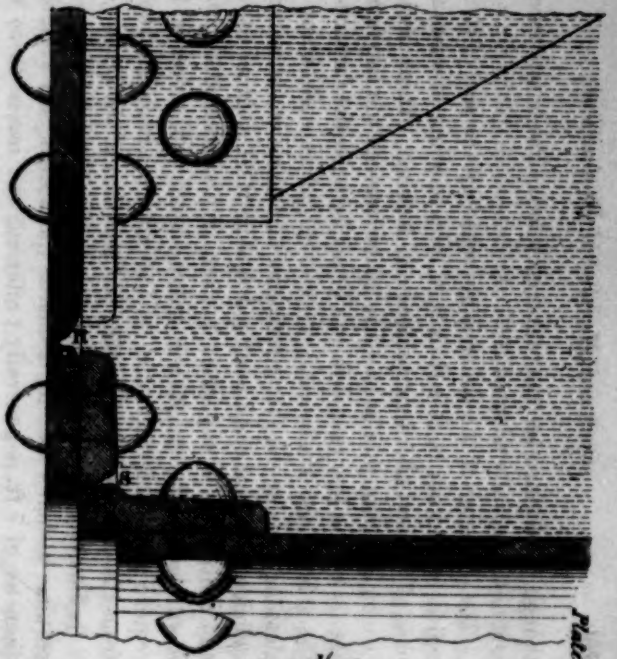
Plate III

Fig. 4. *Inside Elevation.*



(*Proceedings Inst. M. E. 1856*) Scale 1/24th

Fig. 5. *Longitudinal Section.*

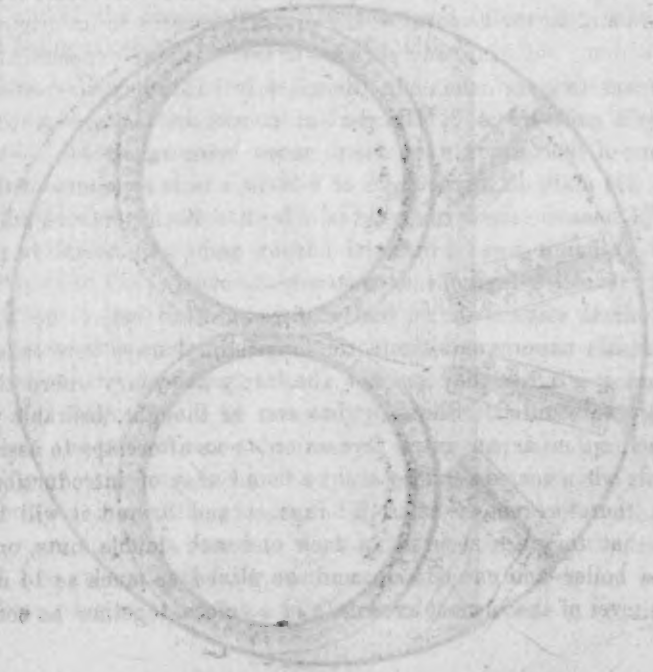


Scale 1/3rd

Plate III

Journal of the Franklin Institute.

Vol. CIII.



most support, but also where it can be held fast without resisting the movements of the furnace-tubes. The part of the end plate that should be left free is that immediately over the furnace crowns. With four gussets, as shown in Fig. 4, the end plate is more unguarded at the centre, which is the weakest part, and more confined immediately over the furnace-tubes, which is the line of motion.

The thickness of the end plates is sometimes as much as $\frac{3}{4}$ in. for pressures of 60 lb. per sq. in. This thickness however is quite unnecessary, and only tends by its rigidity to cramp the furnace-tubes and strain the parts. Half an inch has been repeatedly and successfully adopted in boilers for pressures of 75 lb. per sq. in., and $\frac{9}{16}$ in. when that pressure has been exceeded. These thicknesses have proved amply sufficient.

In applying the hydraulic test to boilers of the construction and proportions now described, before leaving the maker's yard, it is the practice to carry the pressure up to about 150 lb. per sq. in., and to strain fine cords across the flat ends to act as straight edges from which to gauge the ends, measurements being taken at twelve points before the test, during the test, and after the test. It is found as a rule that the plate under pressure bulges outwards at the centre from $\frac{1}{16}$ to $\frac{1}{8}$ in., and on the removal of the pressure returns to its original position without suffering any permanent set. In the experimental hydraulic bursting test, the ends, though only $\frac{1}{2}$ in. thick, have stood repeatedly a pressure of 275 lb. per sq. in. without leakage or any appearance of distress; but on the pressure being raised to 300 lb. the front end plate displayed signs of weakness in the vicinity of the mudhole *A* beneath the furnace-tubes, Fig. 2. With this exception the greatest bulging was $\frac{1}{8}$ in. at the front, and $\frac{3}{16}$ in. at the back, while the greatest permanent set was only $\frac{1}{16}$ in.

Longitudinal stays are frequently introduced to assist the end plates. In the experimental tests the longitudinal stays were taken out, so that it is clear they are not absolutely necessary where the gussets are substantial. Should it however be thought desirable to adopt them, either as an extra precaution or as afterclaps to assist the gussets when too weak, they will be found easy of introduction. They are therefore shown at *B* in Figs. 1 and 3, and it will be observed that they are secured at each end with double nuts, one inside the boiler and one outside, and are placed as much as 14 in. above the level of the furnace crowns, and as close together as con-

venience will allow. When placed directly over the furnace crowns, and only a few inches above them, they confine the furnace-tubes too strictly, and straining ensues. A single stay on the vertical centre line of the front end plate is correct in principle, but two are more convenient in application.

To increase the elasticity of the front end plate, it is attached to the shell by an external angle-iron rather than by an internal one or by flanging. It is not necessary to attach the end plate at the back of the boiler with an external angle-iron, and when this has been done the angle-iron has been found to be injured by the action of the flame.

Both of the end plates, instead of being made in two pieces riveted together at the joint, are welded. This affords a flat surface, which in the case of the front end is more convenient for the attachment of the mountings. Also both of them are turned in the lathe at the outer edge, so as to be rendered perfectly circular, and are bored out at the openings for the furnace-tubes.

Furnace-Tubes.—The longitudinal joints in the furnace-tubes are welded when the plates are of iron, and double-riveted when of steel, each belt of plating being made in one length and thus having but one longitudinal joint. All the transverse seams of rivets are strengthened with Adamson's flanged joint, or with an encircling hoop either of Bowling iron, T iron, or other approved section. Adamson's flanged seam is shown in cross section in Fig. 6, Plate V, the T seam in Fig. 7, the Bowling hoop in Fig. 8, and the Bolton steel hoop in Fig. 9. One of the evils that has attended internally-fired boilers has been the frequent collapse of the furnace-tubes; but this danger is completely avoided by strengthening the tubes as just described, whereby, instead of being weaker than the shell as before, they are rendered stronger. This has been shown by the experimental bursting tests, in which, while the shell has been burst repeatedly, the furnace-tubes have not suffered at all, nor shown any movement on being gauged. In some cases Petrie's water pockets, shown in Figs. 12 and 13, Plate 9, and in others Galloway's conical water pipes, shown in Fig. 11, are introduced as a precaution against collapse; while in others again the water pipes are made parallel, as in Fig. 3, and either riveted or welded in place, so as to form one piece with the flue tube. In all cases however the transverse seams of rivets over

LANCASHIRE BOILER.

Plate IV

Ring Seams for Furnace-Tubes.

Fig. 6. *Adamson Flanged Seam.*

Fig. 8. *Bowling Hoop.*

Fig. 7. T *Seam.*

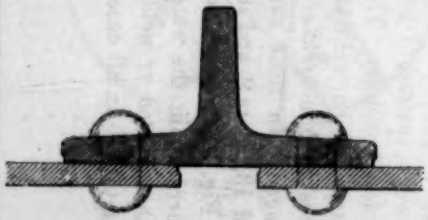
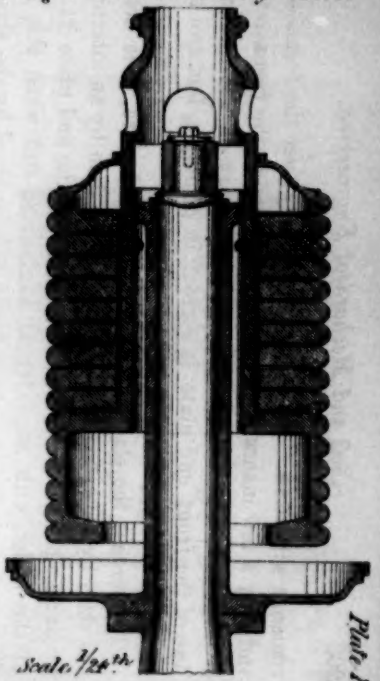


Fig. 9. *Bolton Steel Hoop.*

Fig. 10. *Conburn Safety Valve.*



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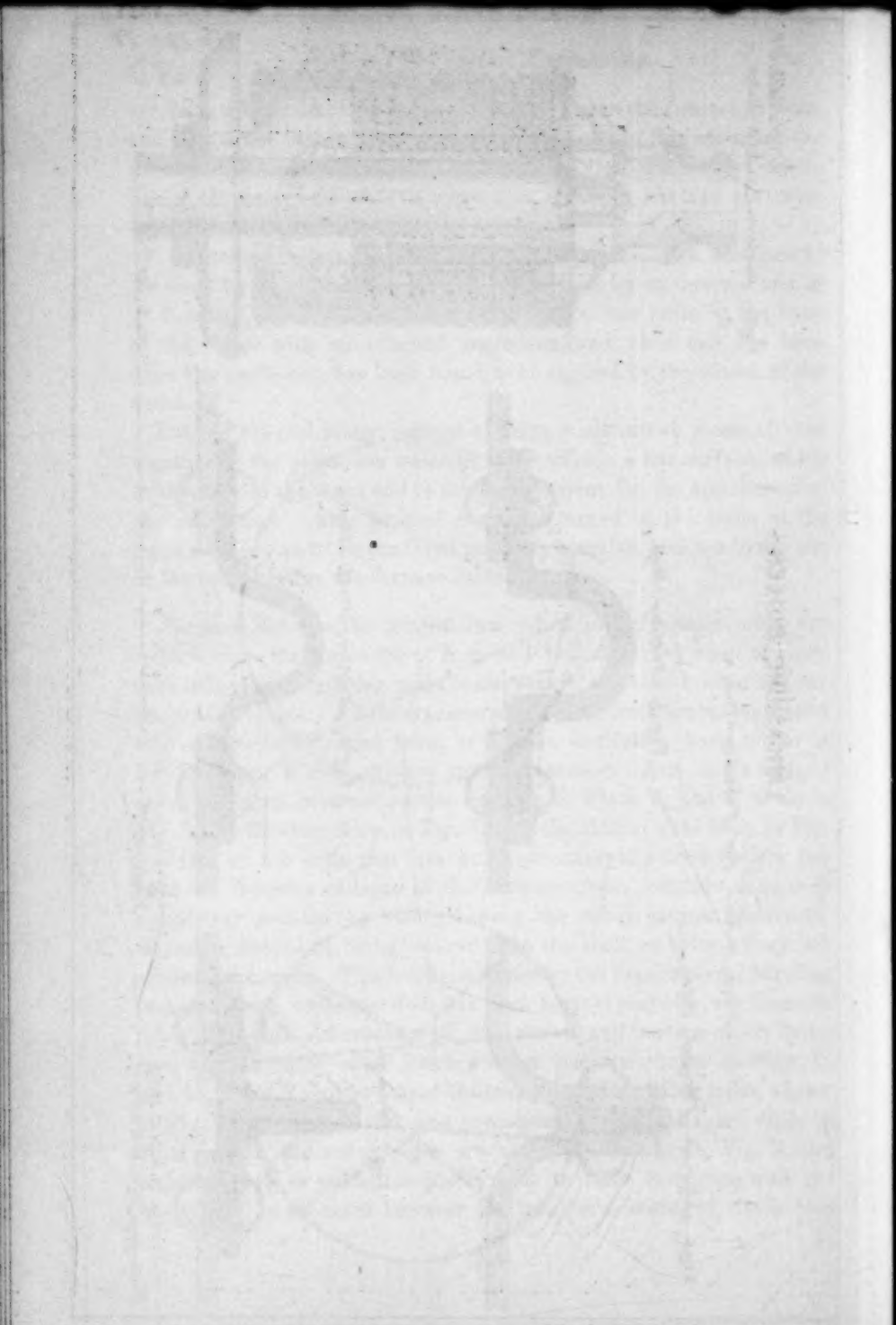
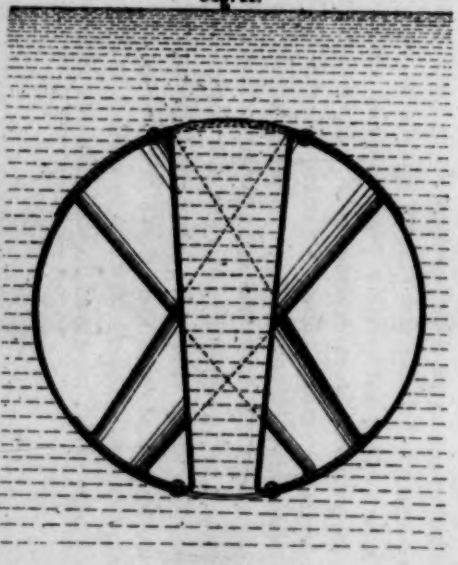


LANCASHIRE BOILER.

Plate V

Galloway Water Pipes.

Fig. 11.



Petrie Water Pockets.

Fig. 12.

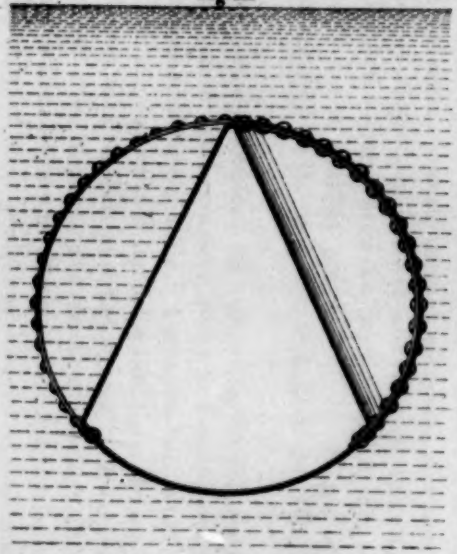
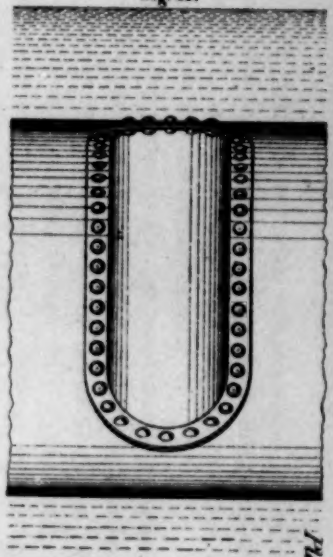


Fig. 13.



(Proceedings Inst. M.E. 1876)

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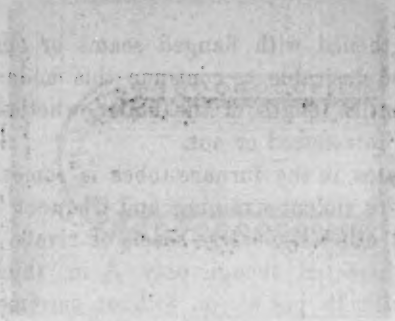
Plate V

JOURNAL OF THE FRANKLIN INSTITUTE.

VOL. CIII.



the fire should be strengthened with flanged seams or encircling hoops; and it is considered desirable to continue this mode of construction throughout the entire length of the boiler, whether water pockets or water pipes are introduced or not.

The thickness of the plates in the furnace-tubes is sometimes as much as $\frac{1}{2}$ in. This leads to violent straining and frequent leakage at the furnace mouths and other transverse seams of rivets. Many furnace-tubes 2 ft. 9 in. diameter, though only $\frac{5}{16}$ in. thick, have stood a hydraulic test of 120 lb. per sq. in. without movement, and have worked satisfactorily for years at a steam pressure of 60 lb. It is advisable however to have them a little thicker than this, in order to afford a margin for waste through corrosion, and also, when the flanged seam is adopted, in order to allow for the thinning that occurs in drawing the metal to make the flange. A thickness of $\frac{3}{8}$ in. is sufficient for a working pressure of 75 lb. per sq. in., $\frac{13}{32}$ in. for a pressure of 80 lb. or 90 lb., and $\frac{7}{16}$ in. for 100 lb. per sq. in.

Stays are sometimes introduced for supporting the furnace-tubes. Such stays however in the Lancashire boiler are unnecessary, and when rigid are decidedly objectionable. Furnace-tubes should be left free to move. As soon as a fire is lighted within them the top of the tube becomes hotter than the bottom and elongates. This makes the tube arch upwards. In conducting a series of trials in 1867 and 1868 for the South Lancashire and Cheshire Coal Association on the evaporative efficiency of their coals, and also on the comparative merits of different boilers, the writer had three gauge-rods attached to the crown of the furnace-tubes of two Lancashire boilers, and carried up vertically through the external shell by means of brass stuffing-boxes, so that a ready opportunity was afforded of witnessing the rise and fall of the furnace-tubes; while as the gauge-rods divided the tubes into equal lengths, a comparison could be drawn as to the movements of the different parts. Constant observation showed that the distortion of the tubes varied very much at different times, being most severe shortly after lighting the fires, while the colder the water to start with, the greater was the rise of the crown. As soon as the water became generally heated the gauge-rods retired to their old position, and the distortion of the furnace-tubes seldom lasted more than an hour. The boilers were 28 ft. long, the furnace-tubes of steel $\frac{5}{16}$ in. thick in one case, and of iron $\frac{3}{8}$ in. in the other. Care

was taken not to strain the boiler by severe firing, steam being got up with the dampers only partially open. Yet the furnace-tubes rose $\frac{3}{8}$ in. when the flames passed around the boiler in the external brickwork flues in the ordinary way, and $\frac{1}{2}$ in. when they passed off direct to the chimney without heating the outer shell. The curve that the flue appears to assume is not a segment of a circle. The gauge-rod at a quarter of the length of the boiler from the front showed in one case as high a rise as the rod placed midway in the length of the boiler, and in another case $\frac{1}{16}$ in. more. This is just what might be expected from the local action of the fire, and accounts for the grooving action being far more severe at the front end of a boiler than at the back, and shows the importance of affording greater elasticity at that part. Furnace-tubes lashed to the shell often tear themselves away from it in ordinary work, and the fractured stay rubbing against the shell leaves a witness of its movements, the amount of which frequently exceeds that just mentioned. In one case a furnace-tube that had a stay tying it to the top of the shell was found to have crumpled up the stay and broken it by an upward thrust, showing how little need there had been for trying to keep the furnace-tube from drooping.

Shell.—The shell, which is $\frac{7}{16}$ in. thick for a pressure of 75 lb. per sq. in., and $\frac{9}{16}$ in. thick for a pressure of 100 lb., is composed of plates about 3 ft. wide, which are laid in not more than three lengths round the circumference, in order that the longitudinal seams may clear the brickwork seatings. The longitudinal seams are so arranged as to break joint and avoid the centre line along the top and bottom of the boiler. In all the longitudinal rents obtained under the experimental hydraulic tests, the plates bulged outwards at the middle of their width, and this action was observed to a slight extent before rupture, showing that the greatest strain and thus the point of first fracture occurred at or near the centre line of each plate. This would seem to show that breaking joint is of practical advantage, and that a boiler composed of wide plates is not so strong as one composed of narrow ones.

There is no steam dome. Steam domes are expensive, they weaken the shell, and often give trouble from leakage at the base. Added to this they are inconvenient in carriage, as well as in revolving a boiler on its seat, as it is sometimes desirable to do for repairs; they

are also inconvenient in covering the boiler over, and in the great majority of cases, if not in every instance, they are for stationary boilers perfectly useless. To prevent priming, an internal perforated pipe *C*, Figs. 1 and 3, is adopted in place of the dome. Under hydraulic pressure with a steam dome 3 ft. diameter, $\frac{7}{16}$ in. thick, and the whole of the shell plate at its base cut away so as to form an opening as large as itself, the flange at the base of the dome ripped at a pressure of 150 lb. per sq. in. At a second trial with a dome of the same diameter, and a portion only of the shell plate cut away, the dome strained so much round its base and caused such violent leakage that a pressure of more than 235 lb. could not be obtained. At a third trial, the steam dome having been removed and refixed with stouter rivet heads, so as to resist the upward strain that was induced, the flange at the bottom of the dome ripped on the centre line of the boiler at a pressure of 260 lb. per sq. in. In this instance the workmanship was all good and sound, but where the quality of the plates is inferior or the domes are attached with reedy angle-irons, the weakening effect must be much greater. Steam domes clearly establish a weak point in a shell, and are better avoided.[1]

The manhole *D*, Fig. 1, is guarded with a substantial raised mouthpiece of wrought iron, welded into one piece, flanged at the bottom and attached to the boiler with a double row of rivets, the thickness of the upper flange being $\frac{1}{8}$ in., and of the body $\frac{3}{4}$ in. This has been found to stand a test of 300 lb. per sq. in. without the slightest indication of straining. A raised wrought-iron manhole mouthpiece is exhibited. It is too frequently the practice not to strengthen manholes with any mouthpiece at all. Many explosions have arisen from this cause, rents starting in the first place from the unguarded manhole, and then extending all over the boiler. The loss of strength

[1] A striking illustration of the weakness of steam domes has recently been furnished by two marine boiler explosions, one occurring on 26th June, 1875, on board the S. S. "Marcasite," the other on 1st July, 1875, on board the S. S. "Renown." In both these cases the steam domes were planted on cylindrical shells, secured thereto by flanging and a double line of rivets. In both cases the dome was blown off, rending all round at the base, the rent running through the inner line of rivet holes for the greater part of its course and through the solid metal at the root of the flanging for the remainder. The diameter of the domes in each case was about 4 ft. and the thickness of the plates $\frac{1}{2}$ in. The dome of the "Renown" blew off at about the ordinary working pressure of 65 lb., and that of the "Marcasite" at somewhat above the ordinary working pressure, but the exact amount is not known.

is owing not simply to the amount of metal cut away by the opening, but also to the action of the cover, which in unguarded manholes is generally internal. This internal cover bears on a narrow edge of plating all round, and is driven outward by the pressure of the steam, and also pulled in the same direction by the bolts in tightening the joint. In fact the cover acts as a sort of mandrel, which being forcibly driven through the manhole splits the boiler open. A heavy hydraulic test shows this action of the cover, by curling the boiler plate up around the manhole. Added to this, the joint is apt to leak, and thus to induce corrosion and thin the plate, which not only reduces its strength but leads to extra force being applied to tighten the joint; several explosions have occurred shortly after the joint has been re-made. It has been the general practice till recently to make raised mouthpieces of cast iron. This however is not wise for the high pressures now in use. A raised manhole mouthpiece having a clear opening of 16 in. diameter, which is the usual size, involves a hole in the shell plate at its base of about 20 in. diameter. The plate in which this hole is cut, unless it be duly strengthened, becomes the weakest part of the boiler when the longitudinal seams are double-riveted, the furnace-tubes suitably strengthened, with encircling rings, and the ends well stayed; so that the stability of the entire structure depends on the mouthpiece: if that fails, the whole structure fails. Under these circumstances it is evidently unwise to risk the safety of the boiler on a piece of cast iron. This view is confirmed by the behavior of cast-iron manhole mouthpieces under hydraulic pressure. Several have failed under the ordinary test at the boiler-maker's yard, while at one of the experimental bursting tests a cast-iron manhole mouthpiece of substantial pattern, measuring $1\frac{7}{8}$ in. thick in the lower flange and 1 in. in the body, rent at a pressure of 200 lb. per sq. in., though the metal exhibited a good sound fracture. This specimen is exhibited to the meeting. It would appear that under pressure there is a considerable upward strain on the plates around the mouthpiece; and that while wrought-iron mouthpieces are able to accommodate themselves to this without distress, cast-iron ones are not. These tests have shown that wrought-iron manhole mouthpieces are much superior to cast-iron, and that the sooner cast-iron ones are generally superseded by wrought-iron the better.

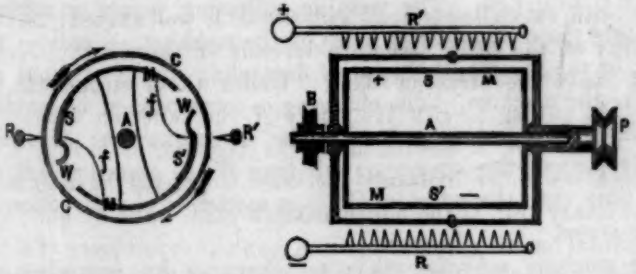
(To be continued.)

Chemistry, Physics, Technology, etc.

CYLINDER HOLTZ MACHINE.

By Prof. ELIHU THOMSON.

The many advantages possessed by induction electric machines, over those producing electricity by friction, have caused the latter to be almost entirely discarded as a source of static electricity. Of these induction machines, the "Holtz" is, perhaps, the best known, and many modifications of this machine have been designed to render it self-charging and constant in action. When, however, the plate form is adopted, the limit to the size of the revolving plates, with the ordinary materials and space that can be allotted, is soon reached. With glass plates the speed of running is limited by the fragile nature of the glass itself.



The form of Holtz machine presently to be described, it is believed, obviates these and other disadvantages, and affords at once a cheap, compact, and portable piece of electrical apparatus, capable of being run at a very high speed, and greatly increasing the electrical power of the machine.

The materials used in the construction are chiefly paraffined wood, and paper or cardboard, also paraffined. When wood or paper is thoroughly dried or baked, and, while still hot, immersed in melted paraffine at above 100° C. until soaked, it becomes, after cooling, one of the best non-conductors of electricity known. The wood so

treated is very strong, and will not subsequently warp or change its form. It is, so to speak, completely waterproofed.

In the figure, *CC* is a hollow revolving cylinder of paraffined paper or cardboard, the ends being made of the same material, or of wood similarly prepared. This cylinder is revolved about a *fixed* axis, *A*, by the pulley *P*. The axis *A* is fixed to the frame of the machine at *B*, and is made of paraffined wood or other insulating material. It serves as a support for the stationary inner cylinder *MM*, also of paraffined cardboard. The cylinder *MM* carries on its inner surface one or more pairs of what are commonly known as sectors or inductors, SS^1, consisting of strips of partially conducting material, placed opposite the outside rows of collecting points RR^1, and provided with the usual pointed projections turned towards the inner surface of the revolving cylinder *CC*. Parts of the inner cylinder *MM*, adjacent to the sectors SS^1, are cut away in a direction from SS^1 opposite to the direction of rotation of the outer cylinder. These open spaces are seen at *WW*. The open spaces or windows *WW*, are not necessary, if the contour of the inner cylinder be that shown by dotted lines *f*, *f*. The supports for the various parts as above described, are all thoroughly paraffined to ensure complete insulation. The metallic collecting points or combs RR^1 constitute the conductors or poles of the machine, + and — respectively, or the reverse, the polarity depending on the original charge given to the machine. The charging is accomplished by holding an electrified body, as a rubbed piece of caoutchouc or vulcanite, opposite one of the spaces or windows *W*, as shown at *E*, at the same time that the cylinder *CC* is in motion in the direction shown by the arrow.

The machine may be made self-charging by providing a small accessory cylinder, revolving opposite the points *E*, on an axis parallel to that of *CC*. The accessory cylinder is made of hard rubber, shellac, sulphur or the like, and is constantly rubbed by an amalgamated cushion, as in the common frictional machine.

A machine constructed as above, with the cylinder about 7 inches diameter and 12 inches long, and run at a moderate speed, gives enough electricity to charge three 1 gallon Leyden jars to a tension of 1 inch in less than four seconds, and may be employed for every purpose where an abundance of static electricity is required.

With a cylinder of 2 feet diameter, and 3 feet in length, it is possible to employ at least four rows of collecting points, each of which will be 30 inches long. A single revolving plate accommodating an equal length of collecting points, would require to be at least 7 feet in diameter. It is evident that the cylinder may be extended in length without adding seriously to its inconvenience.

The form of machine above described may be modified by placing the fixed cylinder and the sectors outside the revolving cylinder, the collecting points being inside the latter, and the conductors carried out at the extremities of the axis, but such an arrangement of parts possesses, it is thought, no peculiar advantages.

A machine constructed of revolving discs of paraffined paper or cardboard, instead of the ordinary plate, has been tried by the writer and was found to give excellent results. It would be quite possible to mount upon one axis a considerable number, say 50 plates or discs of cardboard properly prepared, which, with their corresponding *sectors* and collecting points, would furnish a machine of this character, which, for power, has never been equaled or even approached.

It may perhaps be interesting to remark that, since in the machine described, there is a direct conversion of mechanical energy into electric potential, if electricity be supplied to the machine, the cylinder, if sufficiently free to move, at once begins to turn in a contrary direction to that in which it would produce electricity.

HYDROGEN AND ITS SUBSTITUTES FOR THE LIME-LIGHT

From the *English Mechanic and World of Science*, London, Jan. 19th, 1877.

When making use of the lime-light recently, it occurred to us, says the *British Journal of Photography*, that pure hydrogen could be easily produced while the lantern exhibition was going on. This, we are very well aware, is no new idea, for it has already been referred to in articles in this journal. In the absence, however, of any special apparatus for this purpose, we extemporized a Woulfe's bottle of large dimension, into one neck of which we inserted a long glass tube terminating in a "bell" at the upper end. The bottle, having had several strips of zinc placed in a vertical position inside,

was made rather more than half full with diluted sulphuric acid, when a stream of hydrogen immediately rushed out. By carefully adjusting the emission of the gas a stream of great steadiness was obtained, and this, after passing through a drying-bottle, was conveyed to the burner, where it mixed with the oxygen and yielded an admirable light. From our experience we felt satisfied that with two of these bottles—one to take the place of the other while it is being re-charged with fresh liquid—a supply of hydrogen could be obtained under such pressure and in such quantity as to serve the purpose of an exhibition of several hours' duration. An improvement upon the Woulfe's bottle was afterwards secured in the adoption of a modified form of Döbereiner's lamp. This piece of apparatus, in its ordinary form, consists of a glass jar with a flat metallic cover, into which is cemented the neck of a flask without a bottom. When the jar is covered the flask reaches nearly down to its bottom; the upper end of the flask terminates in a stopcock, attached to which is a fine jet, and by means of a wire a piece of zinc is suspended inside the flask. When the outer vessel is nearly filled with diluted sulphuric acid, and the stopcock opened, the air in the flask is driven out, permitting the diluted acid to come in contact with the zinc, by which is caused an evolution of hydrogen filling the upper portion of the flask, in which it remains under pressure. This pressure, acting upon the surface of the liquid, forces it down beyond the zinc, upon which it has no further action until, by opening the tap and allowing the hydrogen to escape, the acidulated liquid is again enabled to rise in the flask and exercise its solvent action on the zinc, a continuous supply of hydrogen being thus obtained.

But the form of hydrogen-generator, which we found best, was one we had made of wood, lined inside with thin sheet lead, and which was on the same principle as the Döbereiner's lamp, although different in form. It consists of a square and oblong wooden box of the form and dimensions of a microscope case, for which it has more than once been mistaken. It is divided into two compartments by a partition from top to bottom; but, while this partition is soldered to the top and to each side, it does not come quite to the bottom, being distant from it to the extent of nearly a quarter of an inch. At one side of this box or vessel there is provided the means for throwing in scraps of zinc, and at the other a leaden pipe dips down through the top, almost reaching to the bottom. In the former division there is

provided at the top the means for attaching a pipe to convey away the gas. When diluted acid is poured into the vessel, hydrogen is liberated in great abundance in that division containing the zinc, and unless allowed to escape by the tap it exercises such pressure upon the liquid in that chamber as to drive it all into the other half of the vessel—a transition easily effected, as the lower edge of the partition does not quite touch the bottom.

By the length of the tube, or by the compression of the air in the other chamber, the pressure under which the hydrogen is to be emitted can be regulated with ease. Provision is also made to add either zinc or acid without interfering with the steady generating of the gas. It will be found advantageous not to place the partition in a vertical, but rather in a slanting, position. Guttapercha or vulcanite will answer quite well as material of which to construct the generator, although thin sheet lead, backed by wood, will prove more durable, as the diluted acid has no action upon this metal.

One caution we must here append: do not collect the hydrogen for use until all the air has been expelled from the upper part of the generator—a mixture of atmospheric air and hydrogen being explosive.

Electric Lighting.—Although the light now for some time in use in the Northern of France Railway station in Paris is economically obtained by means of the Gramme apparatus, there has been one point upon which improvement has been desired. A single light, as used in Paris, although placed at a great height, necessarily throws many very heavy shadows, which contrast most inconveniently with the blinding intensity of the light within its immediate neighborhood. The discomfort attending the brightness of the light has been somewhat relieved by glass shades, but the shadows are, although less severe, still inconvenient. It has hitherto been found impossible sufficiently to multiply the number of lights so as to avoid these defects, but a discovery has recently been made by M. Jablockhoff which seems destined to bring the electric light into common use. M. Denayrouse has brought the discovery before the Academy of Science, and it seems that it offers, with little extra cost, an efficient means of procuring several lights from one source of electricity, and of regulating the positions of the carbon points. The most delicate part of the electric light apparatus has been this adjustment of the distance

between the carbon points, and it is here that M. Jablockhoff steps in from quite a new path. Instead of placing the carbons end to end, he places them parallel with each other, and separated by some insulating material. The whole is then placed in a cylinder of refractory material in the form of a double carbon wicked candle. By this arrangement the two carbons burn by their lower extremity, there being no necessity for regulators, as the insulating material keeps them at a constant distance. This material as well as the cylinder is consumed in the same time as the carbons, its volatility augmenting the light. Previous to this discovery it was necessary to have a regulator for each lamp, and at great cost, but now a single source of electricity may feed a number of burners, thus permitting of the most effective distribution of the light.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[i]

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. ciii, page 72.]

As an interesting fact we may call to mind, that at the Paris Exhibition in 1867, large quantities of the silico-fluorides of sodium and barium, of soda-ash, and caustic soda were displayed by Tessié du Motay, as products obtained by the application of fluoride of silicon, and hydrofluo-silicic acid on the large scale. The hydrofluo-silicic acid was obtained by smelting silicic acid, fluorspar, and charcoal in a blast furnace, and receiving in water the fluoride of silicon contained in the flue gases,[ii] a process founded on the observations of Bredberg (1829), and Berthier (1835), and elaborated in its details by F. Bothe.[iii]

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[i] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

[ii] Details concerning attempts at the industrial utilization of hydrofluo-silicic acid will be found in the article on the compounds of silica.

[iii] Bothe, *Wagner Jahresbericht*, 1868, 265.

Recently Christy and Bobrownicki[i] have taken out a patent in England, for obtaining ammonia from ammoniacal waters by means of hydrofluo-silicic acid. They precipitate the ammonia from such water by means of hydrofluo-silicic acid, and decompose the precipitate by means of quicklime without the application of heat. Whether this attempt to employ a siliceous compound in extensive chemical operations, will meet with a better fate than its predecessors, time alone must decide. It is the first mention of fluorine in chemical technological literature for the last five or six years.

The application of fluorides seem in fact to be dominated by some hostile influence. Even the use of hydrofluoric acid, for etching on glass, which appeared secure from rivalry, will probably experience considerable limitation in consequence of an American invention. B. C. Tilghmann[ii] uses for etching on glass, and other brittle materials, a jet of sand, violently projected against the surface of the object by means of a current of air, or of steam. (The details of this process are, of course, strictly mechanical.)

Against such a rival fluoric acid cannot possibly maintain its ground for etching, especially where large surfaces are concerned. It will be restricted to the production of fine, delicate designs, such as the graduation of measuring instruments.

The Sulphur Industry of Sicily.

Extracted from the Report of the Mining Engineer, Lorenzo Parodi,[iii] by Dr. Angelo Barbaglia, Professor of Chemistry at the Instituto Tecnico of Rome.

Sulphur is a widely diffused element, which occurs under the most various forms, both in the free and the combined state. In a free condition it forms rich deposits, which may be divided into two classes; such as are found on the surface of the earth in the neighborhood of extinct volcanoes (*solfatare*), forming earthy strata from 6 to 10 metres in thickness, saturated with sulphur, and underground beds (*solfare*), in which the sulphur is so intimately intermingled with the sedimentary rock, that it must be obtained by mining. The latter

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[i] *Ber. Chem. Gesell.*, 1873, 1322,

[ii] B. C. Tilghmann. The sand-blast for cutting hard bodies.

[iii] Sull estrazione dello solfo in Sicilia e sugli usi industriali del medesimo. Relazione dell ingegnére Lorenzo Parodi al Ministro d'agricultura, industria e commercia. Firenze, 1873.

deposits are the more important, and furnish nearly the whole of the sulphur of commerce.

Geology.—The most important sulphur deposits are those of Italy.[1] On the main land are the beds of the Romagna, which yield yearly 120,000 quintals of sulphur, those of Latera, in the province of Viterbo, and those of Scrofano. Beds of sulphur have also been recently found in the provinces of Volterra, Grosseto, and Avellino.

The true home of sulphur is Sicily, where the deposits extend over a great portion of the island, bounded on the south by the mountains Delle Madoni, and comprising almost the whole of the provinces of Caltanisetta and Girgenti, as well as a part of Catania, as far as Caltagirone, Rammacca, and Centuripe. Besides this there are isolated deposits at Lercara, in the province of Palermo, and at Gibellino, in the province of Trapani. The number of sulphur mines scattered in the above mentioned provinces is very considerable. According to a statistical conspectus for the year 1872 the number exceeded 250, with a total yearly production of 1,861,700 metric quintals, requiring an outlay of 2,472,935 lire.

Province.	Annual yield in Metric Quintals. Average of 1869, 1870, and 1871.	Expenditure in Italian Lire.
Caltanisetta,	781,400	1,263,390
Catania,	175,300	326,700
Girgenti,	826,200	763,645
Palermo,	78,800	118,200
	1,861,700	2,472,935

According to the recent, and highly interesting investigations of the mining engineer, Mottura, published in 1871, Sicilian sulphur is a product of the tertiary formation, and is found in the upper miocene between foliaceous crystalline gypsum and massive limestone (calcinari); its associates are bituminous marl (tufi) and gypsum. The sulphuriferous deposits (veins, courses, beds) vary exceedingly in inclination, thickness, extent, and in richness. In these deposits and on their outer boundary, there is invariably found a granular, friable, whitish rock, consisting chiefly of gypsum. The miners of

[1] This statement must be received with great doubts. It is probable that Iceland contains a very much larger quantity of sulphur than Italy.—*Ed. C. N.*

the island name this rock briscale, and suppose that from the purity and thickness which it displays on the surface they can infer the richness and extent of the sulphur deposits. The ores are divided into three groups:—

	Real Percentage.	Yield.
1. Richest, . . .	30—40	20—25
2. Rich, . . .	25—30	15—20
3. Ordinary, . . .	20—25	10—15

Prospecting for Sulphur.—The existence of sulphur underground may be almost always concluded from characteristic indications on the surface. As such the *briscale* is especially regarded, and where it crops out to daylight it is a rule certain to lead to deposits of sulphur. The occurence of siliceous limestone and of sulphur springs are regarded as favorable indications. The first operation consists in driving strongly sloping adits, known by the native miners as *buchi* or *scaloni*. The latter name refers to the circumstance that they are laid out in stairlike flights, which are distinguished as *sani* and *rotti*, according as they run on in a right line, or turn off at an angle.

The Work in the Sulphur Mines.—The miners who raise the sulphur ores are called *picconieri*, and work under the direction of foremen known as *capo mastri*. At the head of the establishment, immediately under the proprietary, there is now generally a scientifically-trained mining engineer. The duty of the picconieri is to split out the sulphur ore from the veins, and to break it up, which is done with heavy hammers (*piccone*), weighing about 6 kilos., and sharpened on one side to facilitate the splitting. Gunpowder is very rarely used except where the gangue consists of the hardest limestone. The adits follow the direction and inclination of the veins, and branch out at places where the ore is rich and easy to work. In this manner are formed a series of spaces known as *gallerie* or *caverne* of every form and size opening into each other in the most various manner. The breadth of these galleries varies from 2 to 2½ metres; their height fluctuates and depends to a certain extent on the thickness of the beds, and especially on the hardness of the rock enclosing the sulphur ores. Where this rock is soft it would be dangerous to give the galleries a greater height than 2 metres, and to prevent accidents the sides are often supported by walls either run up dry or cemented with gypsum.